ARMY GROUND FORCES
MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 5 - 5-29
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COMPARISON OF TESTS OF PHYSICAL FITNESS

1. PROJECT No. 5 - Crew Fatigue, Sub-Project No. 5-29, First Partial Report on Development of Tests to Evaluate the Physical Fitness of Men.

a. Authority - Letter, Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated 24 September 1942.

b. Purpose - To examine critically four suggested tests of physical fitness and to compare the physical fitness ratings achieved by the same men on each of the four tests.

2. DISCUSSION:

Military operations require men who are physically fit, the more fit the better. Owing to the lack of a concrete, universally acceptable concept of physical fitness, much difference of opinion has arisen concerning the methods of determining fitness. As a working concept for this study, the physically fit man was considered to possess the following attributes: (a) capacity for multiple types of work, each on a plane of high energy expenditure, (b) ability to endure and continue such work for considerable periods of time, (c) minimal disturbance of physiologic functions, especially cardio-respiratory and muscular, on the completion of the above work, (d) capacity for purposeful, useful action at the completion of the work. In the light of these considerations four advocated and considerably utilized tests of physical fitness were evaluated on a group of approximately one hundred men. The four tests are: The Army Ground Forces test, the Army Air Forces test, the Navy Step test, and the Harvard Fatigue Laboratory step test.

3. CONCLUSIONS:

a. Men tested by four physical fitness tests (Army Ground Forces test, Army Air Forces test, Navy step test, and Harvard Fatigue Laboratory step test) attained differing and variable ratings by the different tests.

b. Not one of these four tests fulfills the requirements of an ideal physical fitness test. The Army Ground Forces test incorporated the largest number of good features.

c. Motivation plays such an important role in physical fitness

tests that the "will-to-do" may not only mask but entirely determine the fitness rating attained.

d. A physical fitness test is more useful as one of many aids in determining physical fitness than as an exclusive determinant of fitness.

e. An alert, interested officer who has worked with and knows his men is capable of giving a better evaluation of the fitness (both physical and mental) of his men than any fitness test yet devised.

f. Men will strive to attain better scores on repeated testing. The competition thus aroused serves as an incentive to work to improve physical fitness.

4. RECOMMENDATIONS:

a. That this report be made available to all officers upon whom falls the responsibility of the physical fitness of the soldier.

b. That physical fitness tests be considered as aids in improving and determining the fitness of men; that they not be considered as final determinats of physical fitness.

(NOTE: The conclusions and recommendations set forth above have been concurred in by Headquarters, Armored Center, W. H. Nutter, Colonel, G. S. C., Chief of Staff.)

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2 Incls.
#1 - Appendix
#2 - Charts 1 thru 8

APPENDIX

A. EXPERIMENTAL PROCEDURES

1. Subjects - A total of 125 men were tested. All men were healthy enlisted volunteers between the ages of 18 and 33 years; average age 21 years. Seventy-two (72) men were 20 years or younger, forty (40) men were 21 to 25 years inclusive, and only thirteen (13) men over 25 years. They were of all sizes and weights and varied considerably in their physical fitness.

2. Description of tests - The four tests with their scoring techniques are described in the following original communications:

Army Ground Forces test (henceforth called AGF test), Army Ground Forces Letter, October 19, 1942, Training Directive, effective November 1, 1942, Inclosure 7.

Army Air Forces test (henceforth called AAF test), Army Air Forces Physical Fitness Test, AAF Reg. No. 50-14, Sec. 4, Par. 7c.

Navy Step test (henceforth called Navy test), Report entitled Evaluation of Physical Fitness in Terms of Cardiovascular Response and Endurance Time, U. S. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland, December 1942.

Harvard Fatigue Laboratory Step test (henceforth called Harvard test), Report entitled, A Rapid Field Test of Fitness for Work in Hot Climates, The Fatigue Laboratory, Harvard University, February 1, 1943.

The AGF test consists of a battery of six tests performed consecutively in the following order: the number of push-ups, time to run 300 yards in 2 legs of 150 yards each, the number of Burpees in 20 seconds, time to run 75 yards carrying a man of equal weight pig-a-back, time to accomplish 70 yards creeping, crawling, jumping and running in 7 legs of 10 yards each, and a march of 4 miles in 50 minutes. The AAF test consists of three components performed consecutively: number of sit-ups, number of chin-ups, time to run 300 yards in 5 legs of 60 yards each. The Navy test consists of stepping up and down on an 18 inch platform twice every three seconds and is in two components: (1) the cardiovascular index depending on the pulse rate response to 30 seconds of effort and (2) endurance time depending on duration of effort. The Harvard test depends on the pulse rate response to stepping up and down on a 20 inch platform once every 2 seconds for 5 minutes.

An attempt was made to follow each test as described by its author. In a few instances minor details of control (interdiction of smoking for several hours before a test, absence of effort before a test) were purposely not attempted. For mass field testing such controls are not readily attainable.

3. The step tests (Harvard test and Navy test) were performed in an air-conditioned laboratory; the performance tests (AGF test and AAF test) outdoors. During the step tests the men wore only shorts and socks: in the

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performance tests, ordinary fatigue clothing including "G.I." shoes. All tests were carried out in the morning two hours or more after breakfast. On the morning of the fitness test, the men did no other work. The use of tobacco was controlled only to the extent of prohibiting smoking immediately (15-20 minutes) before a test.

4. Sequence of tests - The AAF test, the Navy test, and the Harvard test were always performed on the same morning and successively. There are six different sequences in which three tests may be performed. These sequences were assigned in order as men were tested and the order repeated after the sixth sequence. In this manner, all three tests were equally weighted in regard to order in which they were performed. Once a man had been assigned a sequence of tests, he retained that sequence throughout all subsequent testing. Rest periods of forty-five (45) to seventy-five (75) minutes intervened between two successive tests. This seemed adequate to overcome the acute fatigue of the previous test. The interval between successive components of the AAF test was approximately 3-5 minutes. Because it required the major portion of a morning, the AGF test was run singly and never coupled with another test. Fifteen to twenty minutes usually elapsed between successive components of this test. During the fast march, the men carried a 20 pound pack.

5. Additional performance tests - In a smaller number of men, the performance on these four tests were compared with the performance on (1) a long hike and (2) over an obstacle course. The long hike (32 miles) was along a highway. The men carried 20 pound packs and canteens. They were requested to finish as quickly as possible and were permitted to set their own pace and rests. The time and order of finishing were recorded. The obstacle course was approximately 500 to 600 yards long, contained 17 obstacles and was located on the side of a hill. The test consisted of running the course for speed both once and twice around. The time required and the heart rate on finishing were recorded.

B. RESULTS

1. These tests are evaluated on the principle that physical fitness tests are not sufficiently accurate to detect small differences in the degree of physical fitness between men but rather that they serve to separate the grossly unfit from the average and these two in turn from the very fit. Hence the tests will be examined from the standpoint of their final rating of a man's fitness as poor, average or good. Even such a simple aim becomes difficult in view of the varied scoring terminology of the different tests. One test will classify men simply as "poor, average, and good." Another will attempt a more detailed classification, "very poor, poor, good, very good, and excellent." In this report, the scoring terminologies of all tests have been regrouped into three simple categories; poor, average and good and the men so rated. The terms category and rating are used to designate these groupings.

2. Comparison of ratings attained on several fitness tests. It quickly became apparent that the fitness ratings achieved by the same man often differed from one physical fitness test to another. Indeed the ratings were more likely to be different than similar.

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a. Comparative ratings by Army Air Forces and Harvard tests - One hundred and twenty-five (125) men were tested by both the AAF test and the Harvard test. Chart 1 indicates the number of men rated poor, average and good on each test. A decidely greater number of men attained ratings in the more fit categories on the Harvard test than on the AAF test. This difference is strikingly evident in the number of men rating good and poor on each of the two tests; the AAF test rating few men good and many poor, the Harvard test many good and few poor. Chart 2 indicates the frequency distribution of the scores of these 125 men. In this and subsequent frequency distribution charts (4,6), the boundaries of the three ratings are indicated by heavy vertical lines.

b. Comparative ratings by Army Air Forces, Harvard and Army Ground Forces tests - Of these 125 men, 97 men were tested by the AGF test in addition to the AAF and Harvard tests. The number of men achieving ratings of poor, average and good on each of the three tests is indicated in Chart 3. In this smaller group, the ratings attained on the AAF and Harvard tests retained the same relationship to each other as in the larger group (Chart 1), with perhaps a greater incidence of good scores on the Harvard test. On the AGF test, the scores shifted still further toward the higher categories. Two-thirds of the men were rated good, one-third average and only three men poor. This contrasts sharply with the AAF test ratings of approximately one-sixth of the men good, one-half average and one-third poor. The frequency distributions of the scores on the three tests are plotted in Chart 4 and again the boundaries between categories are indicated by the heavy vertical lines.

c. Comparative ratings by all four tests - Of the same 125 men, 48 men were tested by the Navy test in addition to the AAF, Harvard, and AGF tests. Chart 5 shows the number of men scoring poor, average and good by each of the four tests. The relative proportions of these men placed in each of the three categories by the AAF, Harvard, and AGF tests does not differ materially from that already indicated for the larger groups of men (Charts 1 and 3). Furthermore, the distribution of ratings on the Navy test was similar to that on the Harvard test; both being step tests. In a manner similar to the other frequency distribution charts (2,4), Chart 6 indicates the frequency distributions of the scores on each of the four tests for these 48 men.

Originally 125 men performed the Navy test. The scores of 77 men have been excluded from this analysis because in performing the endurance portion of the test an occasional change of the lifting leg was permitted. These men were tested before we were aware that no change in lifting leg was allowed. Nevertheless, the experience with these 77 men helped formulate our ideas concerning the Navy test.

3. In summary, this experience indicated that the AGF test gave the largest number of good scores, the AAF test the smallest number, with the scores on the Harvard and Navy tests, similar to each other, intermediate between the other two, and closer to the AGF test than the AAF test. The differences in the fitness tests was further emphasized by the differing fitness ratings achieved by the same men on the various tests (Chart 7).

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Generally, only the very poor or the very fit man was rated in the same category by all tests. Most men had received more than one rating on completion of the several tests.

4. Distribution of scores - Some of the inadequacies of the tests or of their scoring methods, or both, arise from an examination of the frequency distribution charts (2, 4, 6) when they are studied not only in regard to the distribution of the scores, but also with respect to the point in the distribution curve where the boundaries of the poor, average, and good categories cut the curves. It is of some interest and importance that the nature of the distribution of scores for each test and the relationship of the poor, average, and good boundry lines to the distribution frequency does not change materially as the size of the group diminishes. In this connection, compare the distribution curves for the AAF and Harvard tests for 125 men (Chart 2) with those for 48 men (Chart 6) or the curve for the AGF test for 97 men (Chart 4) with that for 48 men (Chart 6). This permits the assumption that the small groups give the same conclusions as the larger samples.

The scores of the AAF test have a fairly normal frequency distribution withethe peak blunted into a fairly broad plateau (Charts 2, 4, 6). The poor-average boundary line cuts the distribution curve at the plateau fairly close to its center. The average-good boundary is in a better location, though still a little high on the downward slope. The group with "average fitness" occupies, therefore, a fairly central location in the distribution. Its location could be further improved by shifting the poor-average boundary further to the left, i.e. downward, bringing some poor scores into the average category.

In general, the form of the frequency distribution of the scores of the Harvard test conforms best to the normal distribution (Charts 2, 4, 6). There is, however, the distinct departure of elongated feet skewing at both the high and especially the low ends. The boundaries between categories fall badly. The average-good boundary goes through the peak of the distribution and the poor-average boundary is far to the left in the lower skewing foot. As a result, the group with average fitness scores is not from the central portion of the distribution, but rather from the low to mid portion. This permits most subjects to fall into either the average or good rating and very few into the poor category.

The scores of the AGF test do not conform to the normal frequency distribution (Charts 4, 6). They are crowded at the upper end of the scoring range with considerable skewness at the lower end and an abrupt stop at the upper end. The boundary lines between categories cut the distribution in the same relative position as for scores of the Harvard test. The poor-average boundary is far to the left, near the end of the lower skewed foot, the average-good boundary falls through the peak. As a result most scores fall in the good category.

The scores on the Navy test also fail to show a normal frequency distribution. There is an abrupt start at the lower end, a broad plateau followed by a bad and long skewing at upper end (Chart 6). Both the poor-average and average-good boundary lines fall far toward the lower end of the distribution. As a result, as many, or more, men fall into the long skewed upper end (good) as in the two lower categories (average and poor).

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From the standpoint of results alone, the relatively normal frequency distribution of the scores on the AAF and Harvard tests favors these two as the most desirable of the four fitness tests. A readjustment of the scoring techniques or of the boundaries between categories would permit a better division of men into poor, average, and good ratings (especially in the Harvard test) and perhaps lead to similarity of rating on both tests. The failure of the AGF and Navy tests to give normal frequency distributions of scores indicates deficiencies in their scoring systems. These deficiencies are further intensified by apparent faulty location of boundaries through the distributions, such as they are, The scores on the Navy test suggests a logarithmic rather than arithmetic distribution. A logarithmic scoring system might prove more desirable than the present arithmetic one.

Since it is the function of fitness tests to separate fit men from unfit and average men, a test fails in this purpose when the boundaries of its categories pass through a high point in the distribution curve. When many scores cluster about a boundary, it is relatively easy for a man to slip from one category into another by virtue of a change of a few points in his score but with no real change in his fitness. All four tests here considered have at least one such improperly placed boundary.

4. Predominant role of performance in the fitness tests. The AAF and AGF tests are purely performance tests. The Harvard and Navy tests are advocated because of their physiologic components. However, in each of these tests, performance plays a more important role than the physiologic response. Thus, in the Harvard test, if the subject can continue the exertion for the required five minutes, he cannot score less than average regardless of his heart rate or state of exhaustion on completion of effort. Similarly, in the Navy test, the index (final rating) is influenced more by the endurance time (duration of effort) than by the cardiovascular response (physiologic component of the test). Chart 8 indicates this.

5. Field performance tests compared with physical fitness tests.

a. Endurance hike (32 miles) - The performance of 22 men on an endurance hike did not correlate in any way with their scores on the four physical fitness tests. For example, a man in this group who routinely scored last or next to last on the four fitness tests finished first on the hike, one hour and 10 minutes ahead of a man who scored 3rd to 5th highest in the fitness tests. A long hike of this type taxes endurance alone and lacks the other components of a good fitness test.

b. Obstacle course - Twenty-two (22) men performed this test in addition to the four fitness tests. Again there was no systematic correlation between the performance on the obstacle course and the scores on the fitness tests. Some of the best men on the fitness tests scored high on the obstacle course but in others, this did not hold. Several men who had mediocre ratings on the fitness tests scored near the top on the obstacle course.

C. DISCUSSION:

1. This brief study does not pretend to solve the problem of physical fitness or the methods of determining and testing fitness. It has rather served

to focus thinking on this complex subject. The following ideas which have emerged from experience with these tests rather than the above results, are considered the important portions of this report.

It has already been suggested that the physically fit man differs from the physically unfit man in the possession of the following attributes: (1) capacity for work on a plane of high energy output and involving the use of many muscle groups, (2) ability to continue such effort for a long period of time (endurance), (3) minimal disturbance of cardio-respiratory and muscular functions during work, (4) capacity for purposeful and useful action at the close of effort. An ideal test of physical fitness should: (1) tax all components involved in physical fitness, (2) tax each component on a plane of high energy output, (3) place reasonably equal stresses on all men, (4) give equal ratings in all environments, (5) show higher scores with improvement in physical condition, (6) be independent of the personal element, particularly motivation. The practical requirements of the army necessitate that the test be simple to apply, score and evaluate and require few men to administer it. Let us see how each of the four tests fulfills these requirements.

a. Hard work involving many muscle groups - The step tests (Harvard and Navy tests) have the disadvantage of limiting the work to a particular group of muscles, the legs and back; and in the Navy test to one leg alone. In the Harvard test, the work is on a plane of high energy expenditure; but in the Navy test, one may question the severity of effort involved in the 30 seconds of work required in the cardiovascular response and the 120 seconds of effort which gives a rating of good in the endurance time. These two tests are designed to determine the adequacy of the cardiovascular mechanism to strenuous muscular effort. This requires that the cardiovascular systems of all men be submitted to the same stress. However, in these tests, the stress placed on two cardiovascular systems will not be equal when the muscular efficiency of the limited regions exercised by these tests differs in the subjects tested. Differences in the muscular efficiency of the legs and back are common among men.

Furthermore, men were repeatedly encountered who made excellent scores on the step tests, yet performed badly when called upon to use their arms and shoulders, as in chinning. These men were fit in the legs and back but not in the shoulders and arms; hence, not generally fit.

The AAF test involves a greater part of the body; arms and shoulders, back and abdomen, and legs. Certainly the shuttle run requires much effort, the chinning and sit-ups considerably less. The AGF test involves practically the entire body in a battery of tests, each of which place a considerable stress on the man. It has the advantage that the work done is of the type the soldier will be required to do.

In general, a battery of tests is superior to a single test requiring only a specific type of work.

b. Endurance - Endurance is a relative concept and since these tests are actually of short duration (a matter of minutes) one may question whether endurance is being tested. The required five minutes of effort in the Harvard

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test certainly represents good "endurance" for short severe work. The 120 seconds of effort required for a score of "good" on the endurance component of the Navy test hardly seems to test this factor. Neither the sit-ups, chins, or 300 yard shuttle run of the AAF test place a call on endurance. The AGF test, requiring several hours to complete and running through a battery of 6 tests ending with a march of 50 minutes, most nearly approaches a test of endurance.

c. Minimal disturbance of physiologic functions - The AAF and AGF tests are strictly performance tests. They do not take into consideration the cost of that work to the man in terms of disturbance of his physiologic functions. In these tests, a man in poor physical condition but with great will power may push himself hard enough to attain a score which is better than his actual fitness would warrant when one takes into account the marked physiologic changes (e.g. rapid heart rate) induced by the effort. The scoring systems of the Harvard and Navy tests are dependent on the physiologic changes induced in the cardiovascular system by the effort. However, in each of these tests the performance factor (duration of effort) predominates in the calculations.

d. Useful effort after hard work - None of these tests considers whether a man is capable of useful work after finishing severe physical effort. Some, like the performance tests, require only that the man finish. The man who finishes relatively fresh and is capable of further useful, coordinated effort is rated no higher than his colleague who finishes and then collapses. This also applies to those tests in which the scoring is based on the pulse rate response to effort. Attention is focused entirely on the pulse, the man neglected. For example, one man may be capable of carrying on usefully with a pulse rate that is higher than that of his neighbor who is exhausted even though his heart is beating more slowly. The latter man would receive the better score, but the first man is the useful one and, therefore, the best one. In one of the British fitness tests, the soldier fires at a target when he reaches the end of a battery of tests. The score on the firing enters into the final rating. This appears to be a useful addition to fitness tests. In a battery of tests, each succeeding test is, in some measure, an indication of the ability to continue purposeful and useful action after the preceding test.

e. Equal stresses on all subjects - The AGF and AAF tests place reasonably equal stresses on all subjects, but the Harvard and Navy tests decidedly handicap the short-legged, small men. It is mechanically more difficult for the man with short legs to step up and down on a 20 or 18 inch platform than for a long-legged, tall man. These tests do not, therefore, impose equal stresses on all men.

f. Effect of environment - When heart rate enters alone, or in major portion, into the scoring of a test, that test is likely to give lower scores in hot environments where heart rates tend to be rapid. In these environments, however, rapid heart rates are anticipated and do not carry the same significance as equally rapid heart rates in cooler environments. Some adjustment of the scoring for hot environments seems desirable.

g. Learning and training - Some men quickly learned to perform the step tests in a way which required the least expenditure of energy. These men tended to rest for a moment on the platform, rather than on the floor. The

descent was almost a relaxed fall, the bounce of which was utilized to assist in the next step-up. Many men who made the best scores used this technique. By a skillful trick they had learned to do less work and so defeated the supposed equality of the test for all subjects. The learning factor, or development of skill, seemed less likely to influence the scores on the AAF and AGF tests. However, some components of the AGF test (e.g. zig-zag run) lend themselves to improvement through learning.

h. Motivation - In all of these fitness tests motivation or the will-to-do, is such an all-important factor that it may not only mask the true state of physical fitness, but actually outweigh all of the factors so that the test becomes one of mental drive rather than of physical fitness. This was seen repeatedly in all four tests but particularly so in those tests having no definite end point; e.g. the number of sit-ups in the AAF test, the duration of effort in the Navy test. The importance of motivation in determining the final score and rating cannot be overstressed. Repeatedly it alone changed a man from one category to another. In all of these tests, the duration of effort or the speed of effort plays a large part. It is the will which drives a man to continue in the face of the discomfort induced by effort. On one occasion he may decide, be induced or goaded into continuing in the face of discomfort and so attain a good score. On another occasion he may decide that there is no reason to endure discomfort, quits early when the going begins to get tough and achieves a poor score. Yet his physical fitness has not changed.

i. Of the four physical fitness tests here studied, the AGF test probably has incorporated in it the largest number of the components of a theoretically good fitness test. It has two marked deficiencies; (1) the failure to include an evaluation of the induced physiologic disturbances and (2) its present scoring system. Adding a physiologic component and adjusting the scoring system would strengthen the test.

2. Role of physical fitness tests - We now come to a critical question: Do these physical fitness tests separate the physically fit from the physically unfit? If they do, they are useful. If they do not, are they useful? There is general agreement that the tests will not differentiate between the finer degrees of fitness. Proponents of the various tests claim that an unfit man will never make a good score, nor a fit man a poor score on their tests. The first part of this statement is probably true, at least for the tests here studied--a physically very unfit man will not get a good rating of any test. However, fit men did at times obtain poorer scores than their fitness warranted. The difficulty has been that the tests have not been restricted to this simple interpretation and have been increasingly utilized to differentiate the finer differences in fitness between men.

Fitness tests seem of much more value as adjuncts, aiding with other observations, in arriving at a final concept of the physical fitness of men than as final determinants of their fitness. A coach or trainer knows not only the general fitness of his men but learns to determine even minor fluctuations in that fitness. An alert officer, interested in his men, working with them over a long period of time, observing their performance under a variety of physical stresses is in the best position to know the fitness

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(physical and mental) of his men. His ratings of their fitness would seem superior to those determined by an uninterested observer handling the men for only the short period of time while he is evaluating their responses to arbitrary, often artificial, fitness tests. Too often the prime purpose of the subject under test becomes one of beating the score; of figuring ways to achieve the highest scores rather than that of learning his actual state of fitness. The place of fitness tests would seem to be (1) to assist the responsible officer in screening out the very unfit and (2) to serve as one of many tools which he would utilize to determine the fitness (both physical and mental) of his command. Fitness tests serve one other purpose. They arouse competition and the incentive to better one's score is a strong inducement for men to undertake physical effort and training.

On the background of a general overall physical fitness it is advisable by further training to develop an added special or superior fitness of those particular parts of each soldier's body which will be utilized in his particular task. Part of this added fitness will be as physical fitness per se, part will be in the development of skill in performing a given task. The latter point is of great importance.

By learning the most skillful method of performing his given tasks, the soldier then becomes capable of doing what is required of him not only well and quickly but with a minimal expenditure of energy. There is, consequently, a husbanding of his fitness for future tasks. The development of the skillful performance of duties should not be lost sight of in the attempt to attain maximum physical fitness.

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CHART I

COMPARISON OF PHYSICAL FITNESS RATINGS ATTAINED
BY 125 MEN ON AAF AND HARVARD TESTS

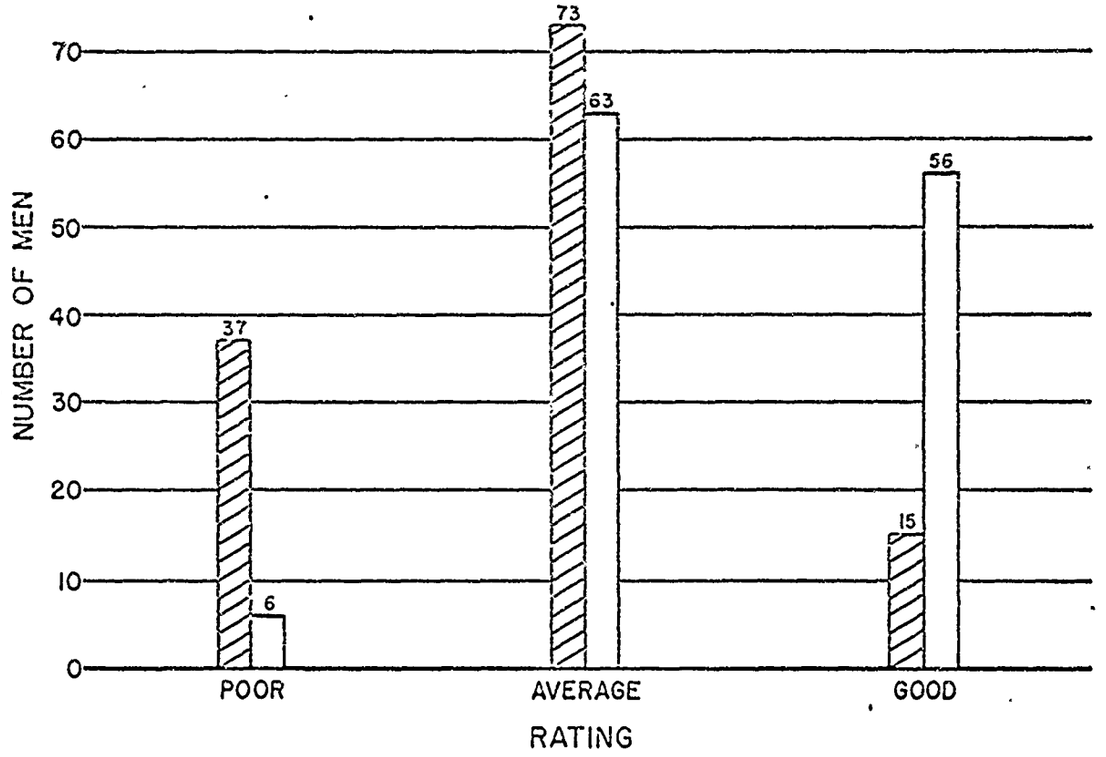

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CHART I

CHART 2

FREQUENCY DISTRIBUTIONS OF SCORES ATTAINED BY 125 MEN ON AAF AND HARVARD TESTS

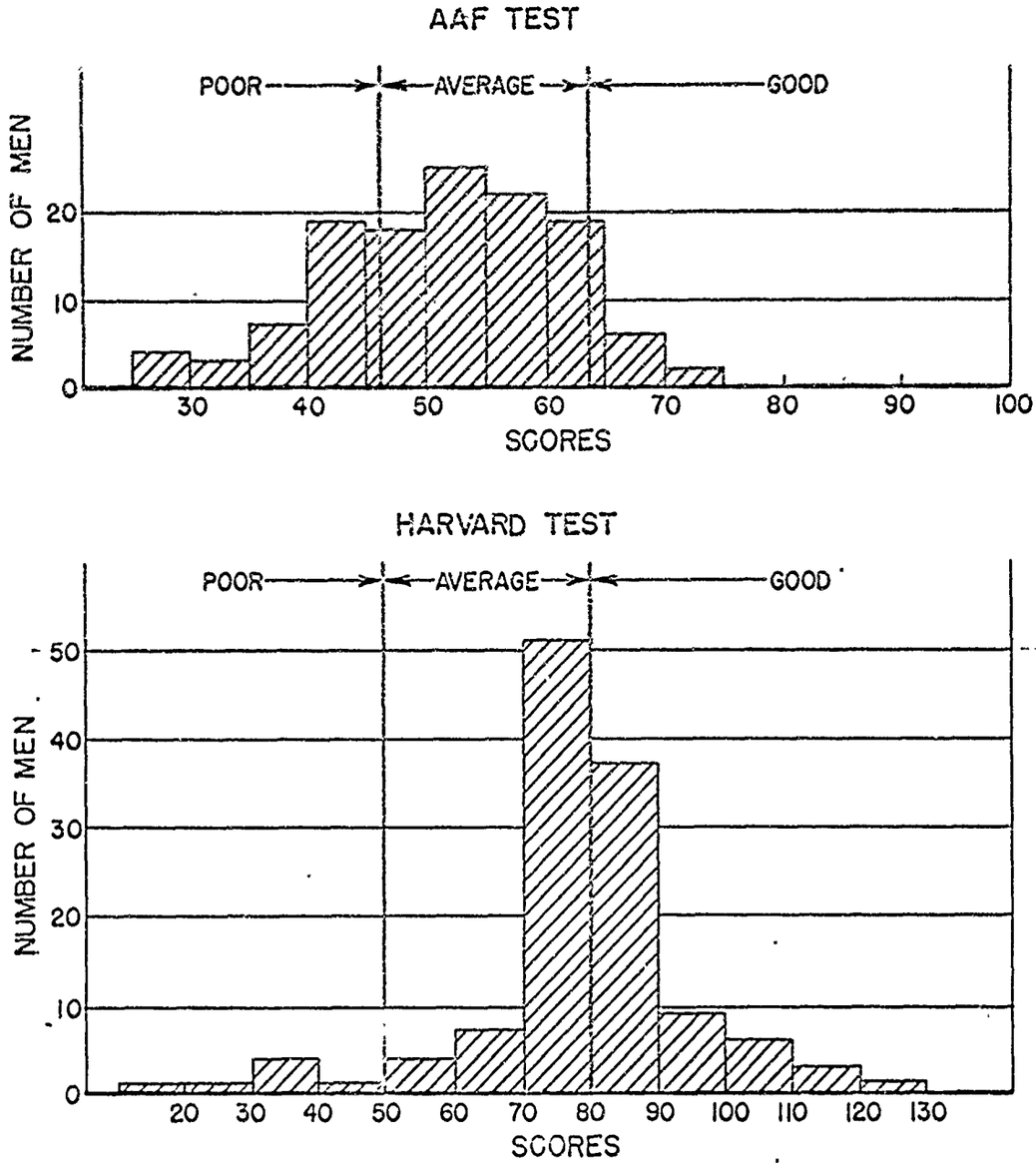

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CHART 2

CHART 3

COMPARISON OF PHYSICAL FITNESS RATINGS ATTAINED BY 97 MEN ON AAF, HARVARD AND AGF TESTS

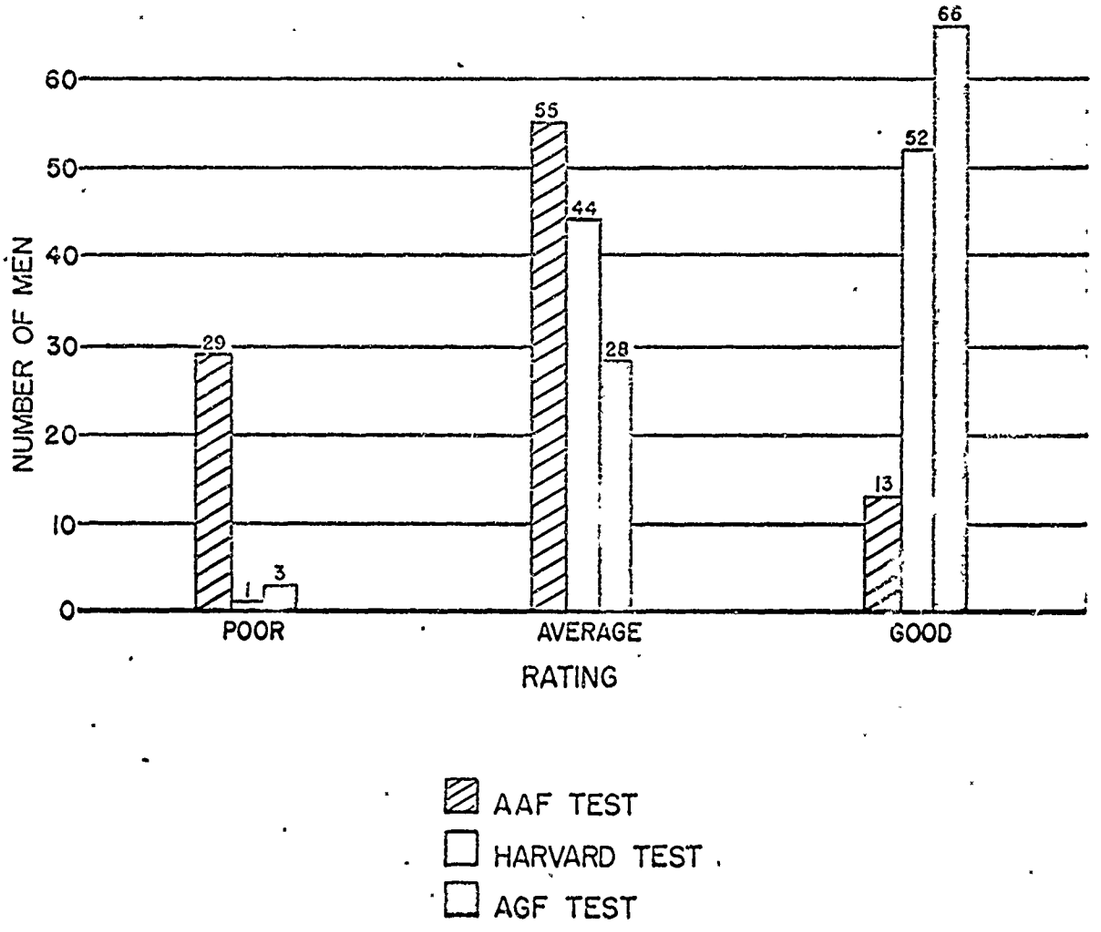

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CHART 3

CHART 4

FREQUENCY DISTRIBUTIONS OF SCORES ATTAINED BY 97 MEN ON AAF, HARVARD AND AGF TESTS

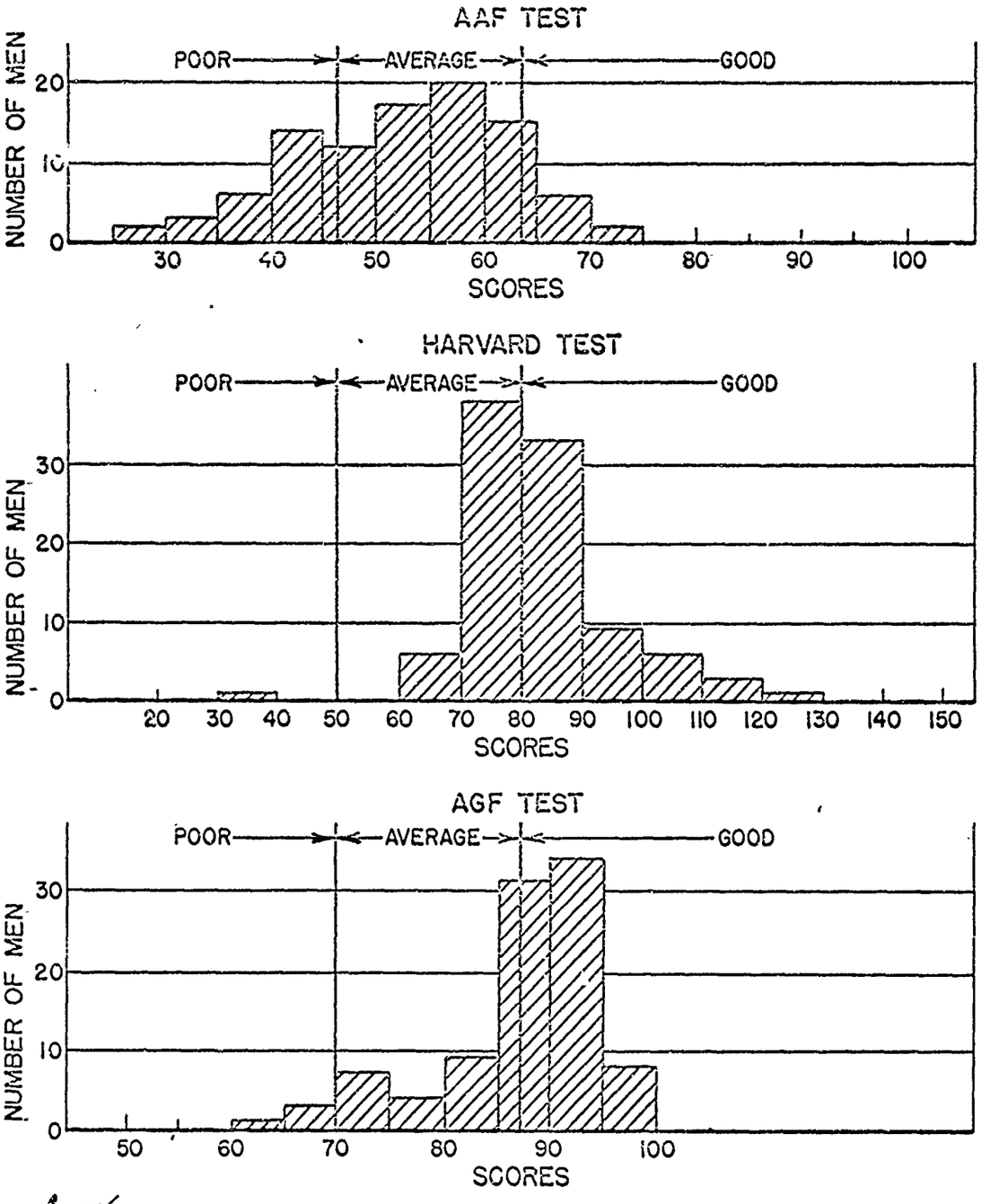

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CHART 4

CHART 5

COMPARISON OF PHYSICAL FITNESS RATINGS ATTAINED
BY 48 MEN ON AAF, HARVARD, AGF AND NAVY TESTS

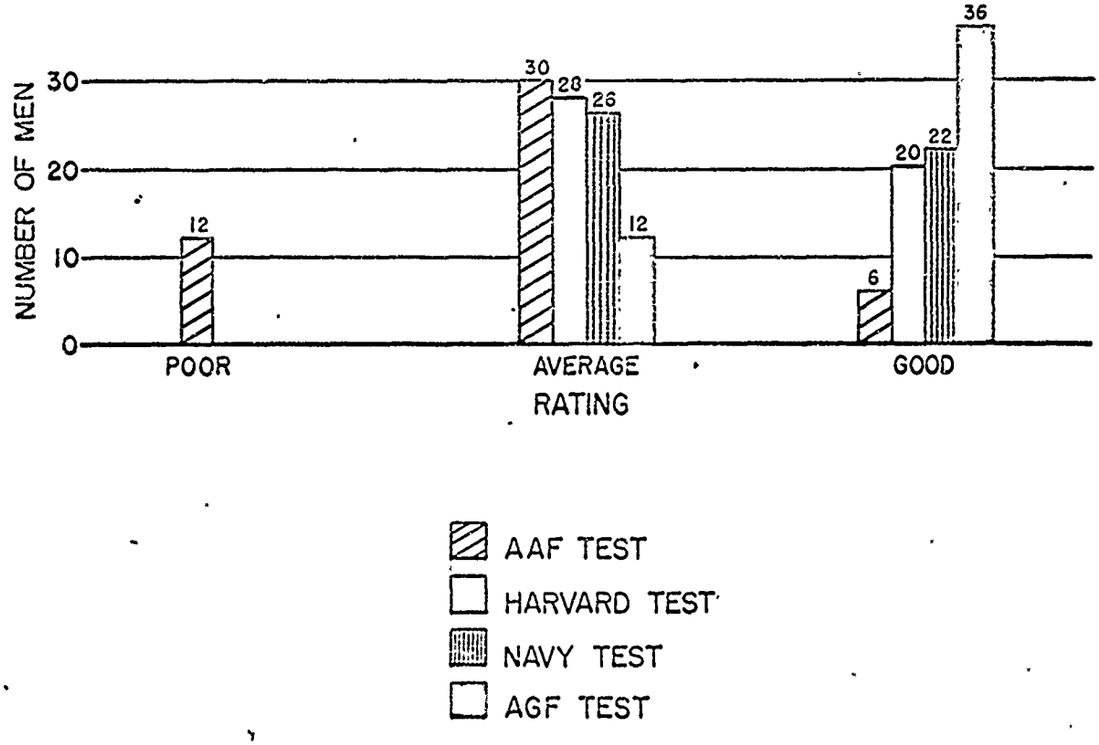

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CHART 5

CHART 6

FREQUENCY DISTRIBUTIONS OF SCORES ATTAINED BY 48 MEN ON AAF, HARVARD, AGF AND NAVY TESTS

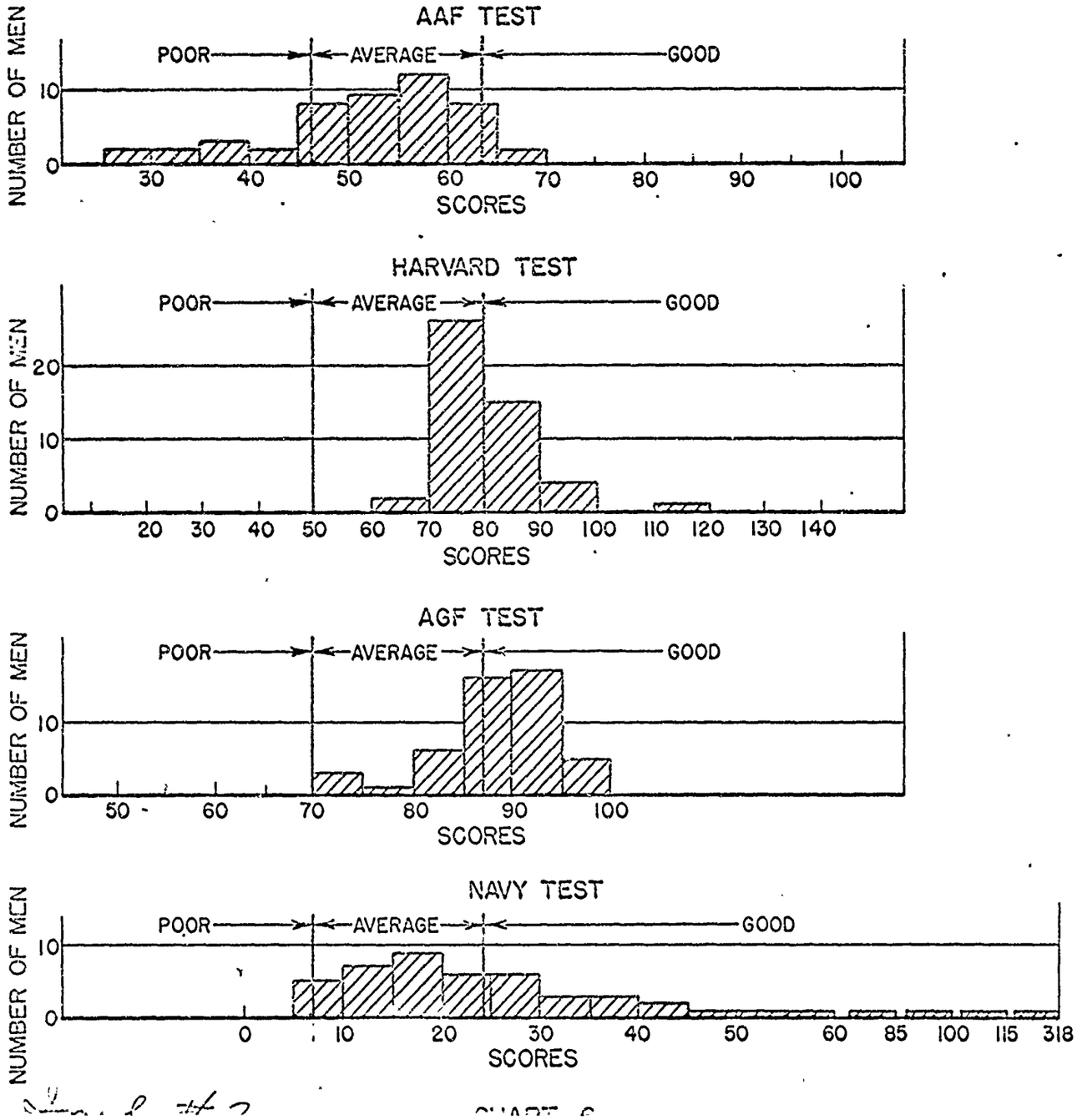
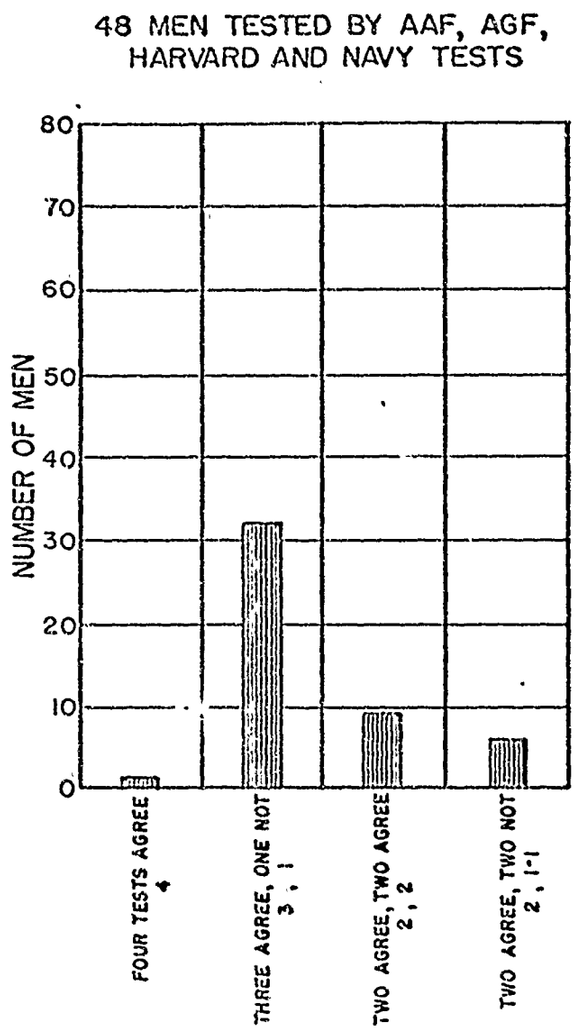
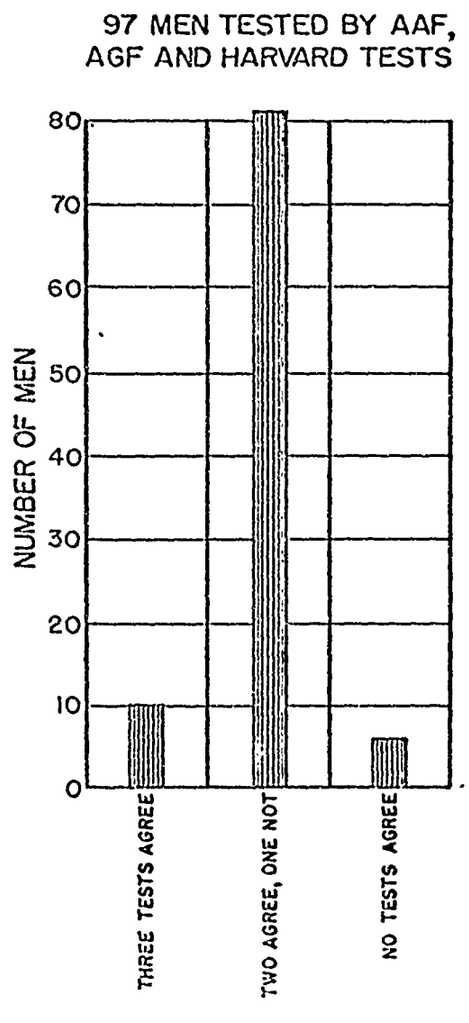


CHART 7

FAILURE OF AGREEMENT IN PHYSICAL FITNESS RATINGS ACHIEVED BY THE SAME MEN ON VARIOUS FITNESS TESTS





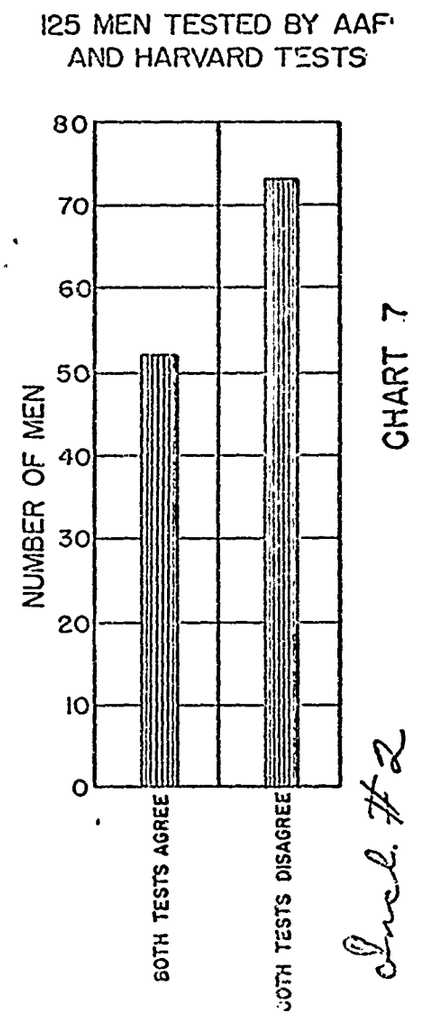


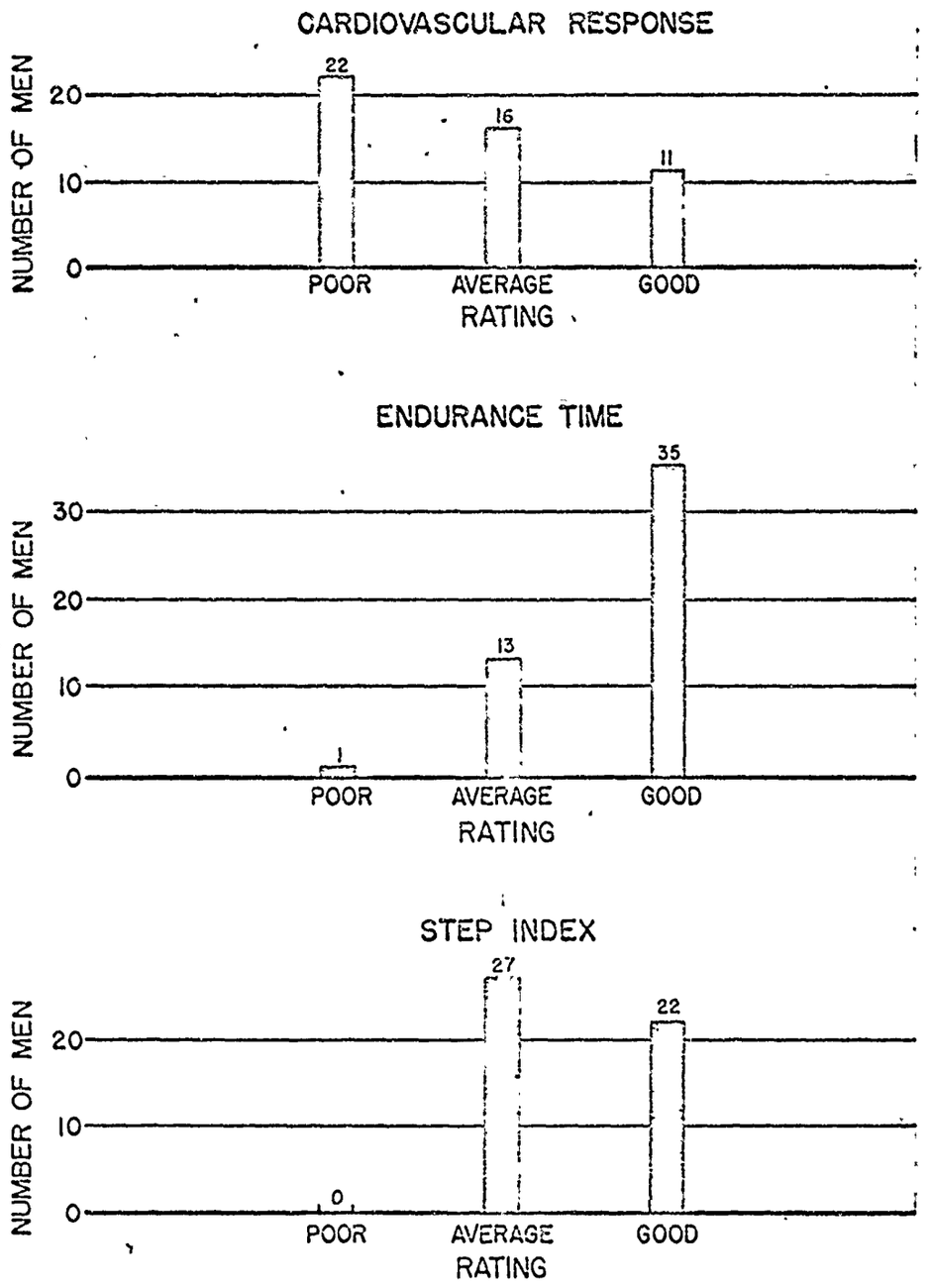
CHART 7

Encl. #2

CHART 8

RELATIVE IMPORTANCE OF CARDIOVASCULAR SCORE AND ENDURANCE TIME IN EVALUATION OF PHYSICAL FITNESS (STEP INDEX) BY NAVY TEST

(49 MEN)



Incl. #2

CHART 8

CHART - 8

THEORETICAL CURVES

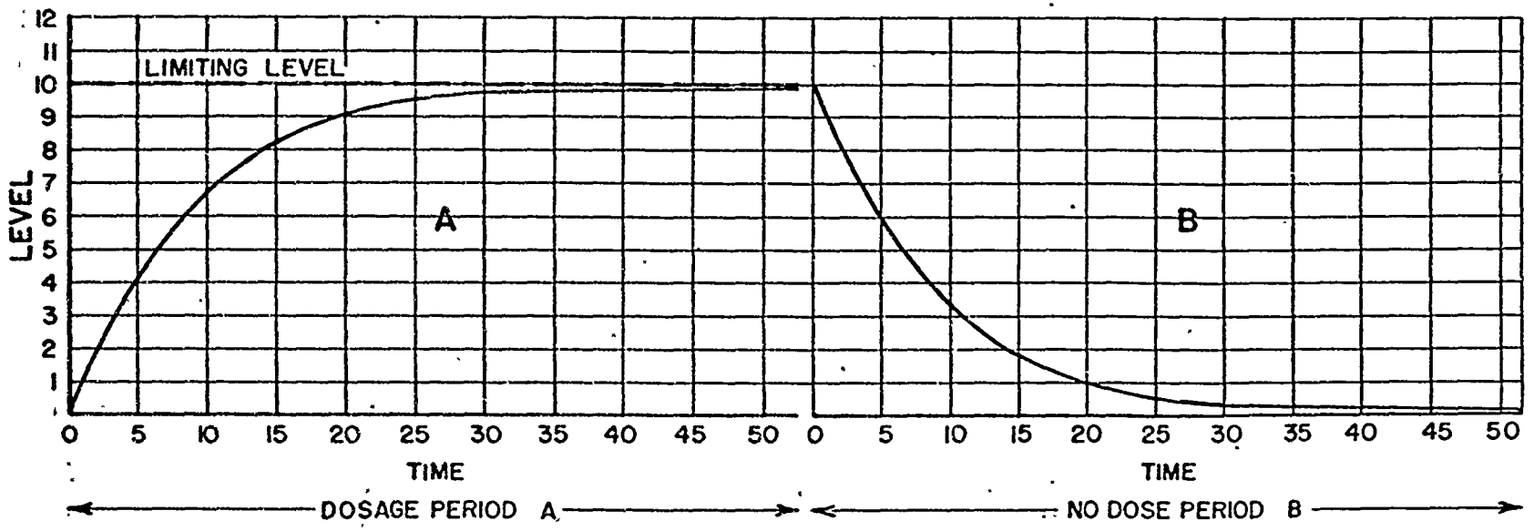
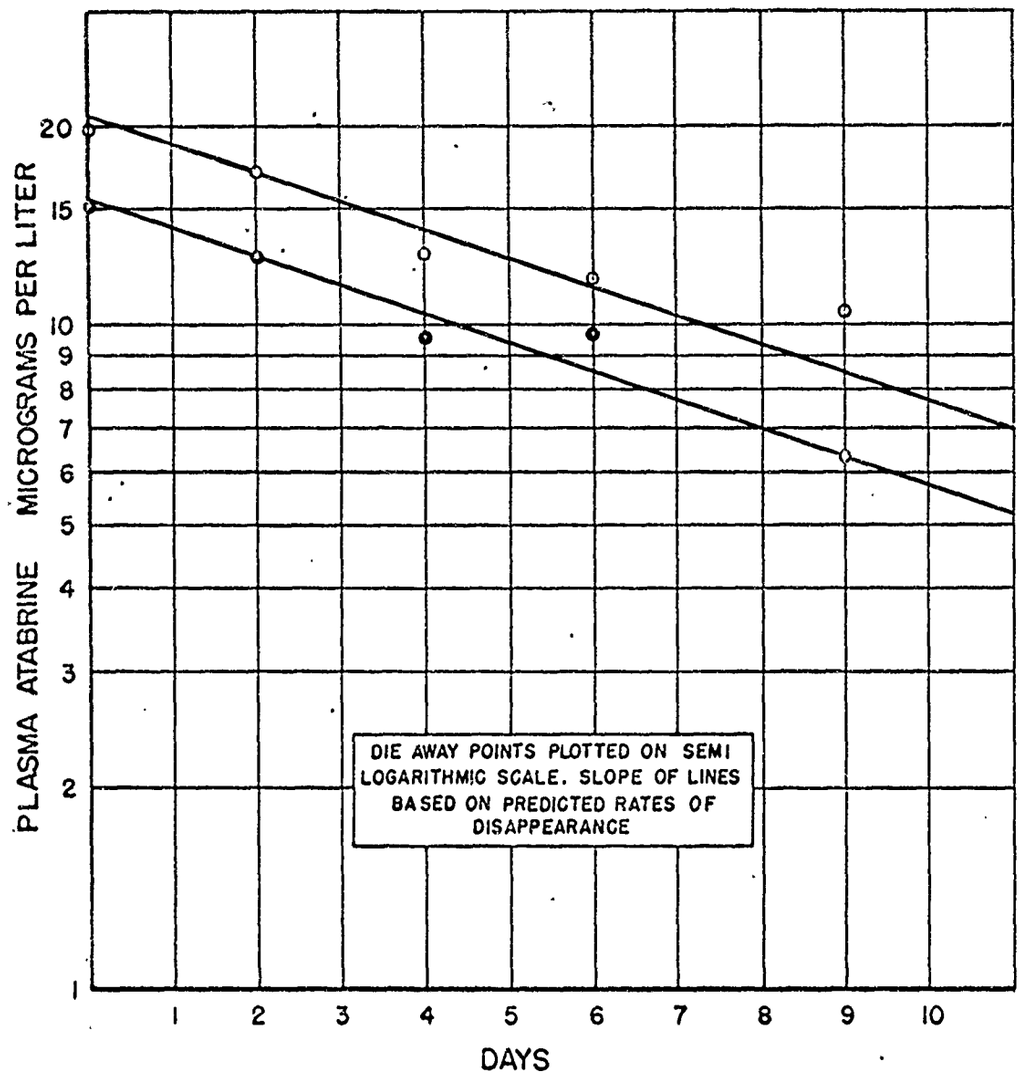


CHART - 8

CHART - 8

CHART -9

EXPONENTIAL NATURE OF THE DISAPPEARANCE OF ATABRINE FROM THE PLASMA WHEN DOSAGE IS DISCONTINUED



COMPANY C, SECTION 2 ○ (0.6 GM GROUP)
COMPANY C, SECTION 1 ● (0.4 GM GROUP)

CHART -9

CHART- 10

POST ABSORPTION CURVES OF PLASMA ATABRINE CONCENTRATION FOLLOWING 0.2 GM DOSE

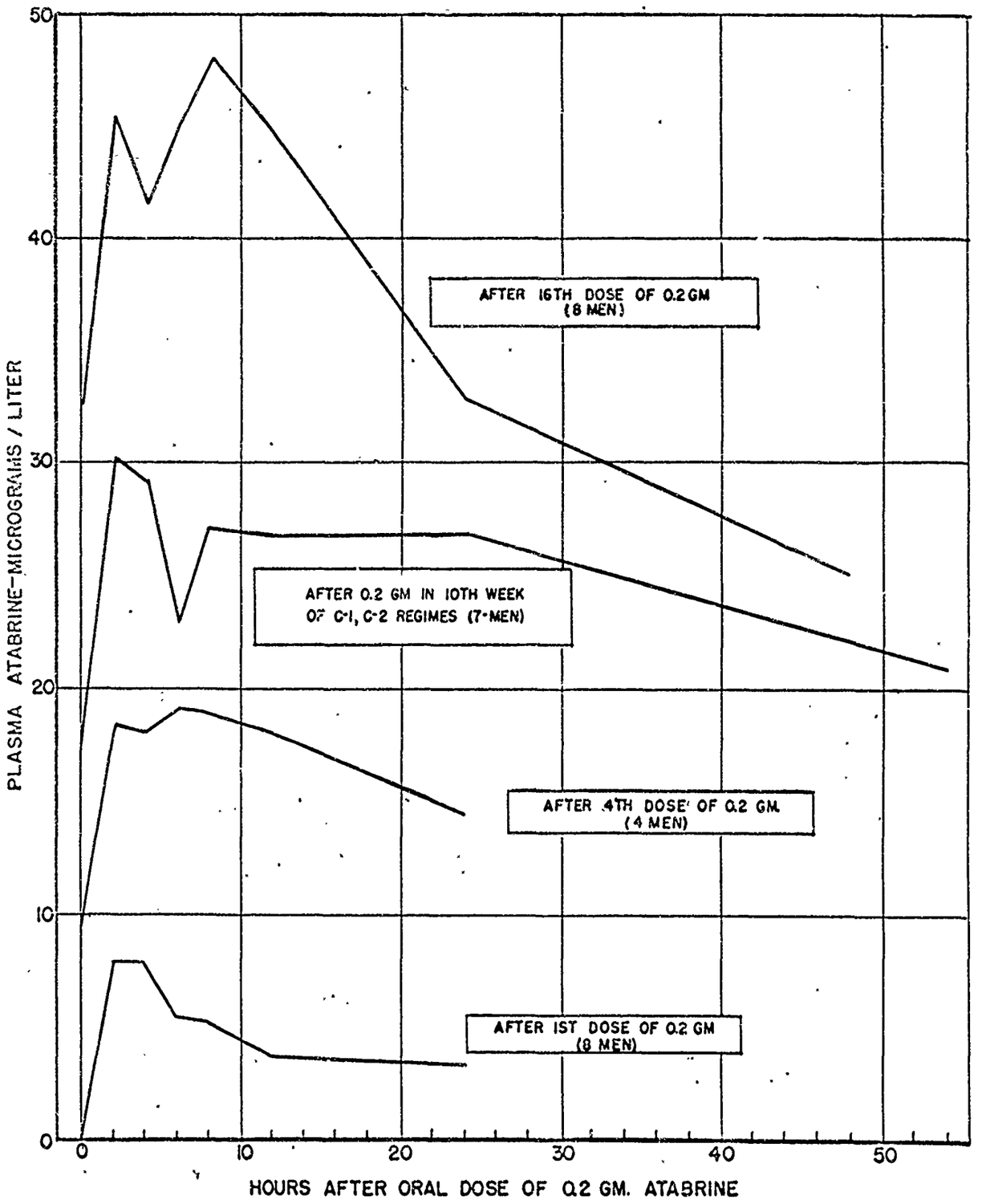


CHART- 10

CHART – II

TRANSIENTS FOLLOWING SINGLE DOSE 0.2 GM.

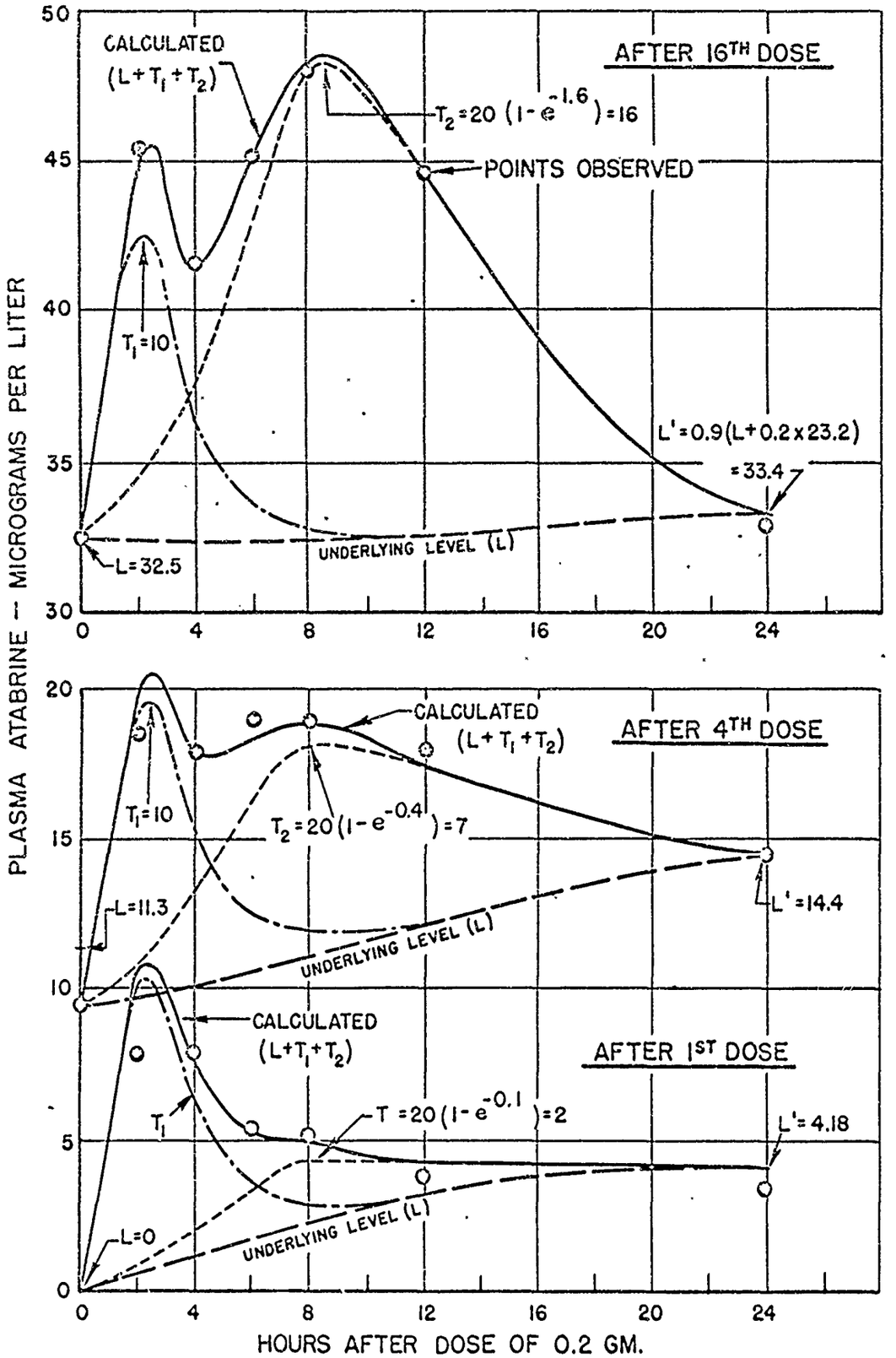
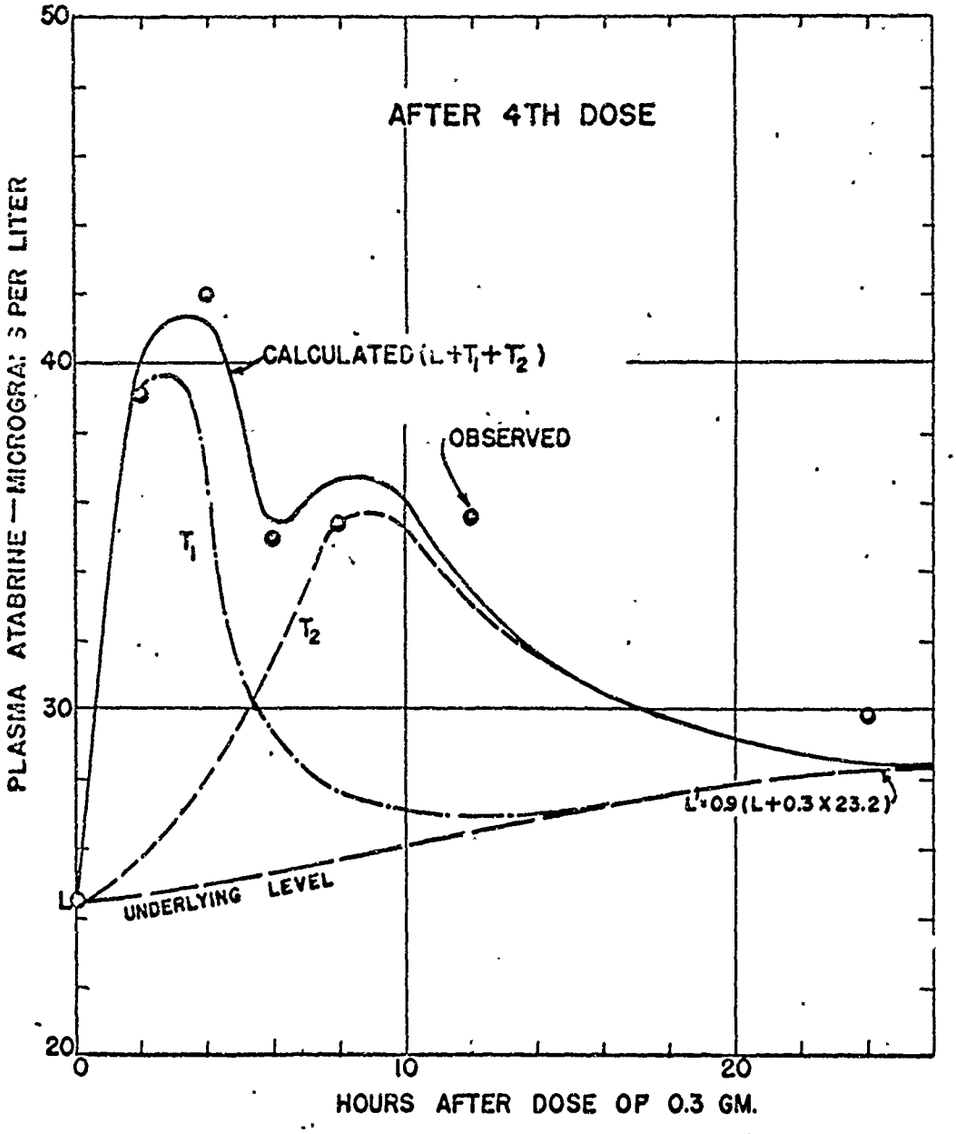


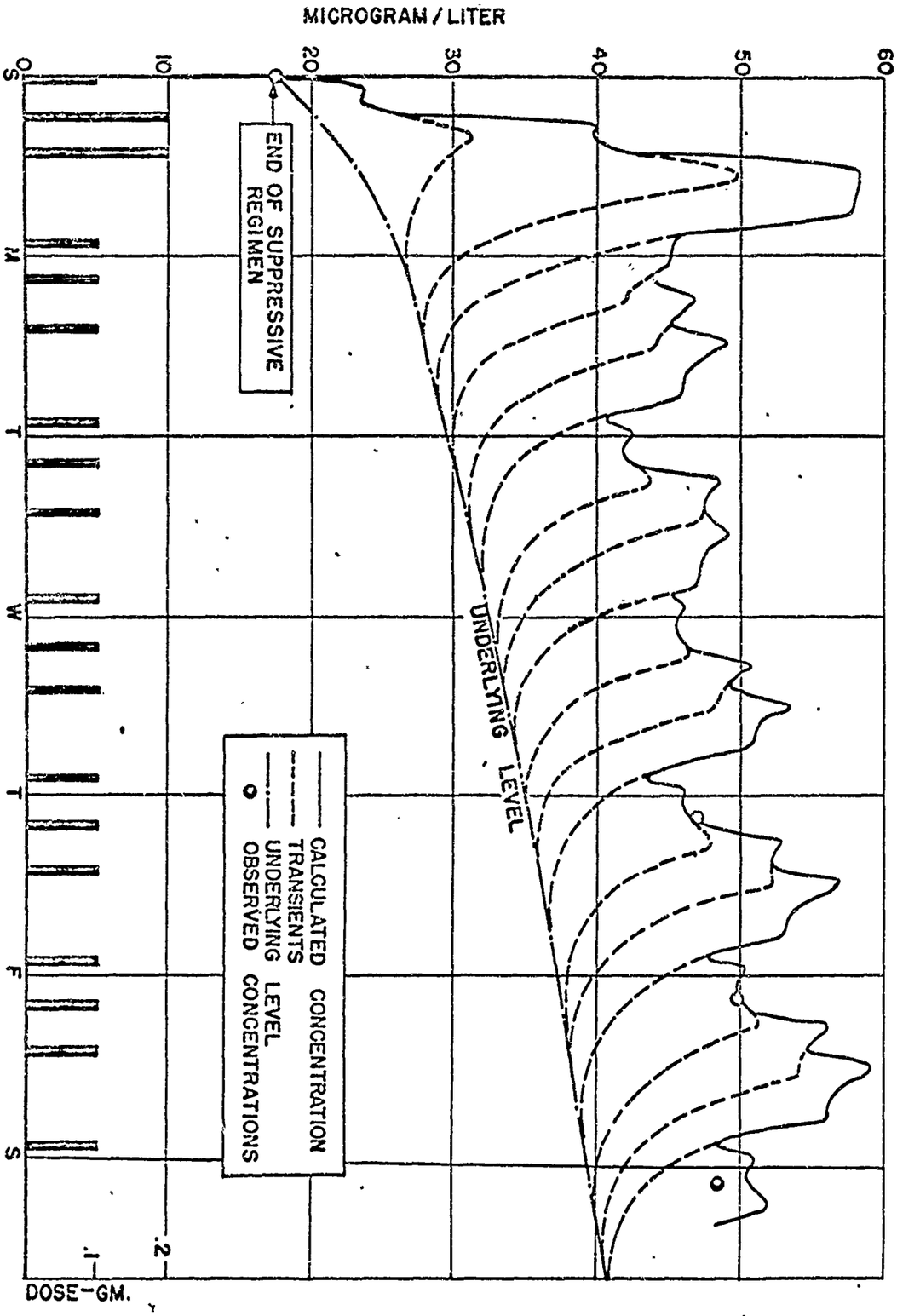
CHART – II

CHART–12

TRANSIENTS FOLLOWING SINGLE DOSE 0.3 GM.
CALCULATED CURVES—OBSERVED POINTS



CHART–12

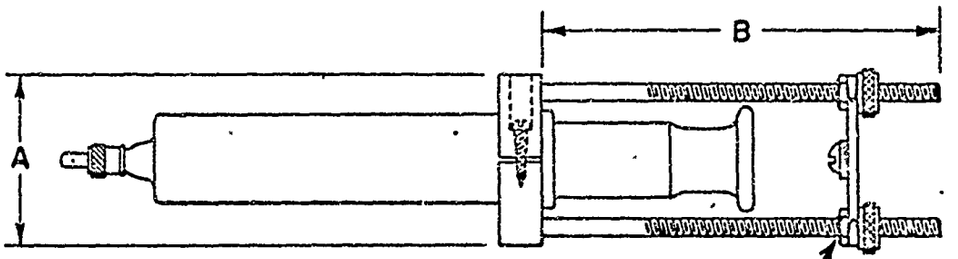


THEORETICAL RESPONSE TO THERAPEUTIC REGIMEN

CHART-13

CHART-13

SYRINGE PIPETTE

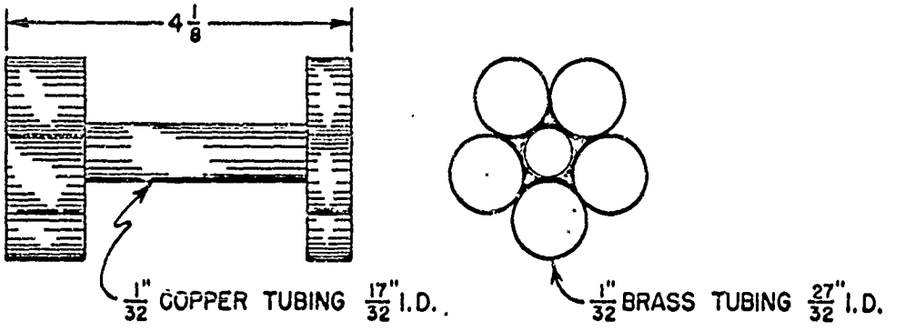


DIMENSIONS A - B

10 ML.....$1\frac{9}{16}$.....$4\frac{3}{8}$

30 ML.....$1\frac{7}{8}$.....$4\frac{5}{8}$

INSERT TO ADAPT 250 ML TRUNNION CUPS TO CARRY 5 TEST TUBES



WEATHER DATA FOR THE MONTHS OF THE EXPERIMENT

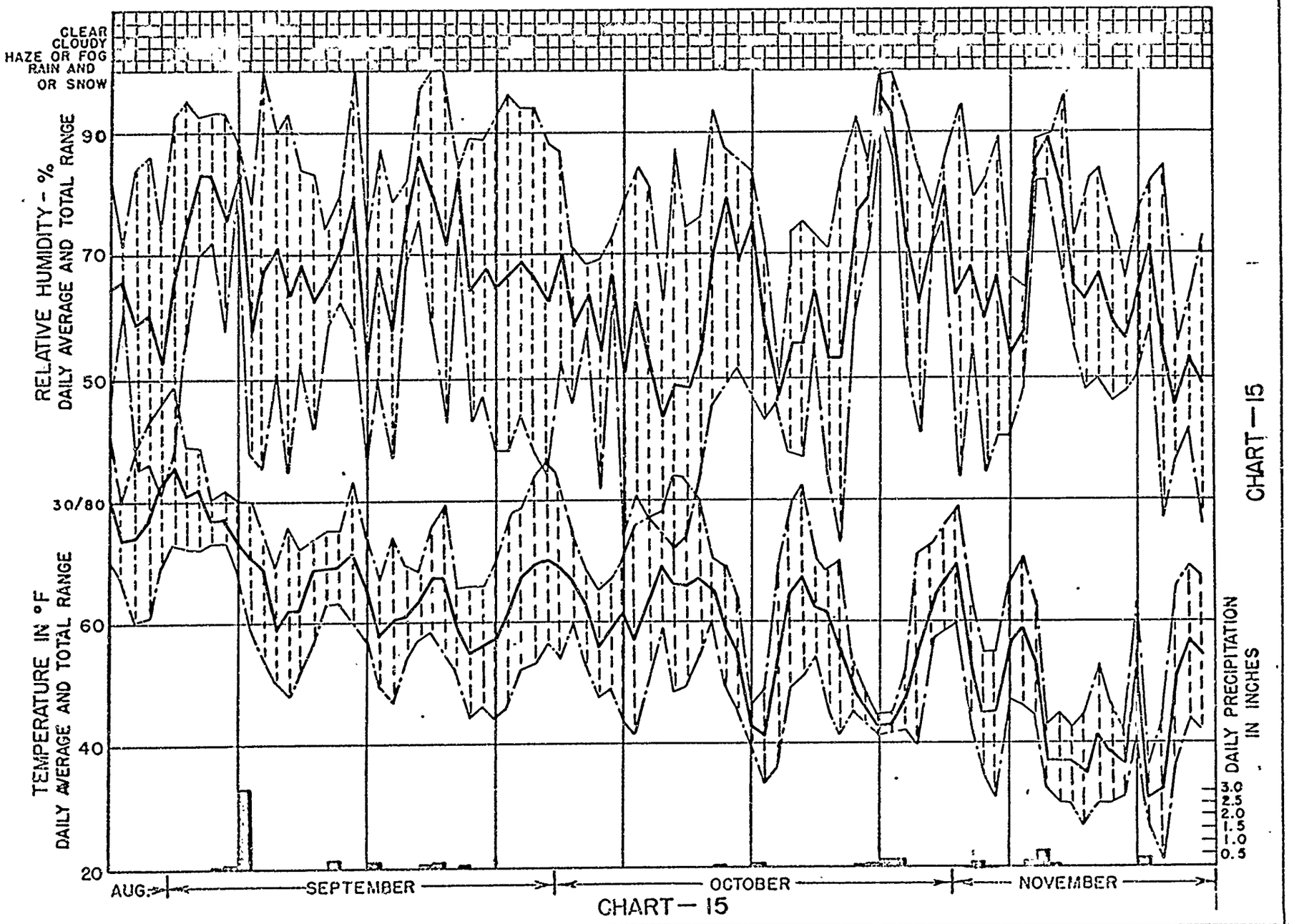
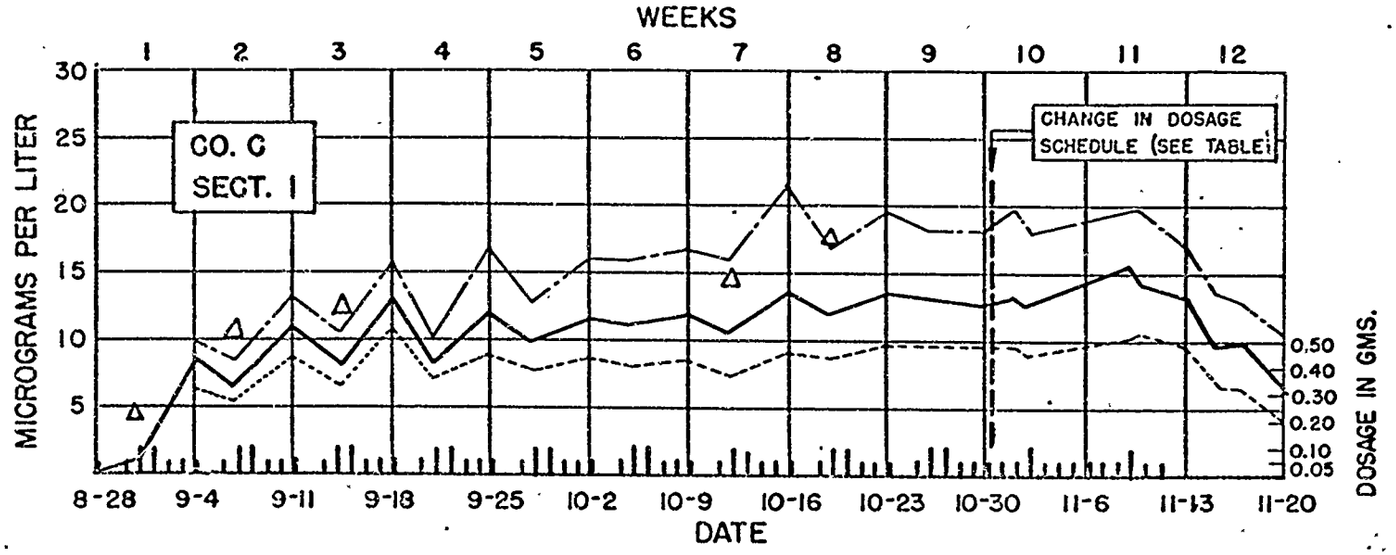


CHART — 15

MEAN$_G$ PLASMA ATABRINE LEVELS OF TWO GROUPS OF MEN RECEIVING 0.4 GM./WEEK.



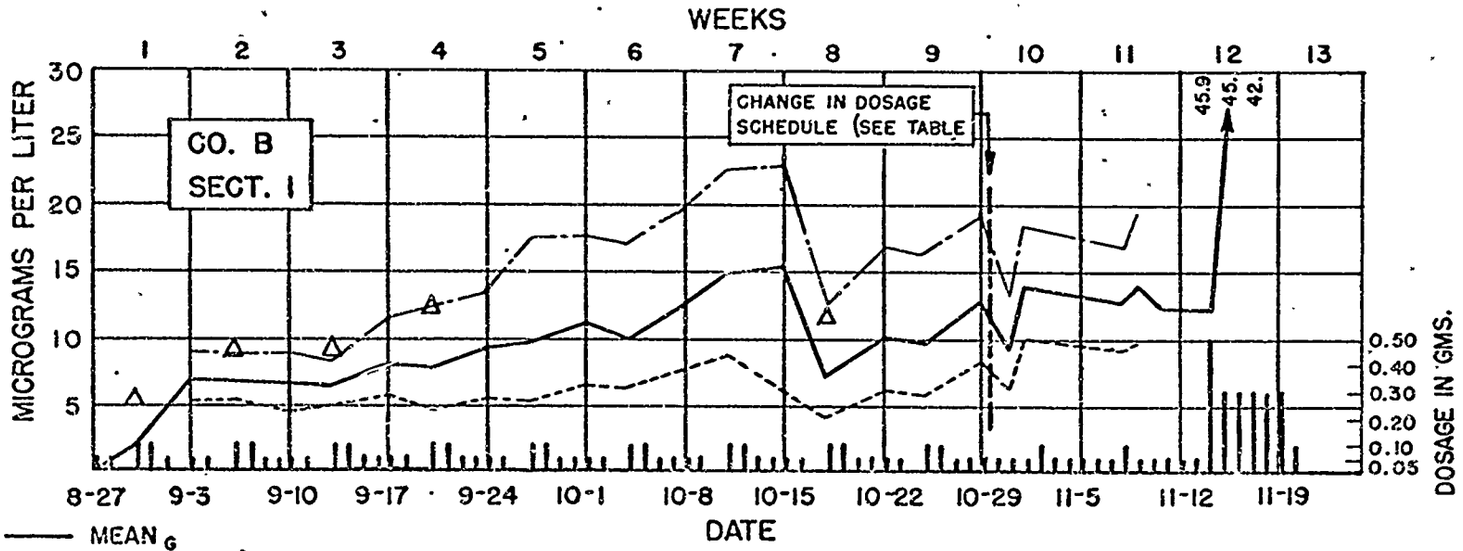
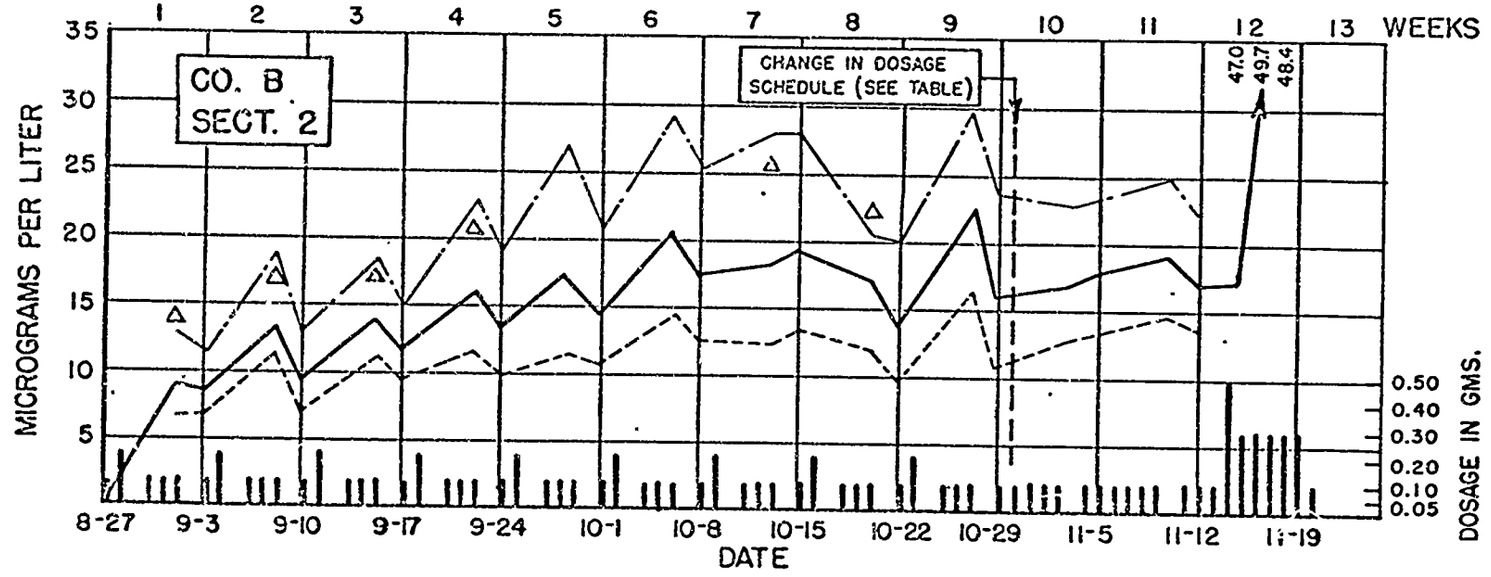


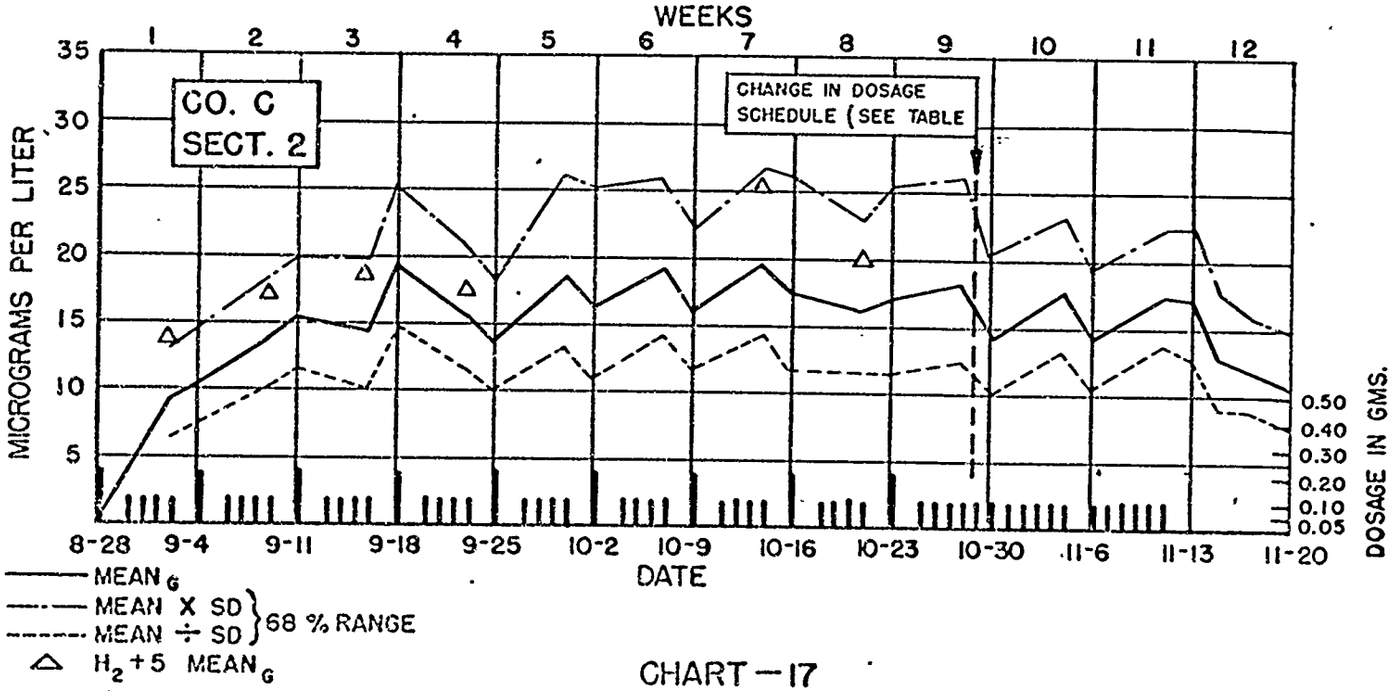
CHART – 16

MEAN$_G$
MEAN $\times$ SD
MEAN $\div$ SD
68 % RANGE
Δ H_2 + 5 MEAN$_G$

CHART – 16

MEAN$_G$ PLASMA ATABRINE LEVELS OF TWO GROUPS OF MEN RECEIVING 0.6 GM./WEEK



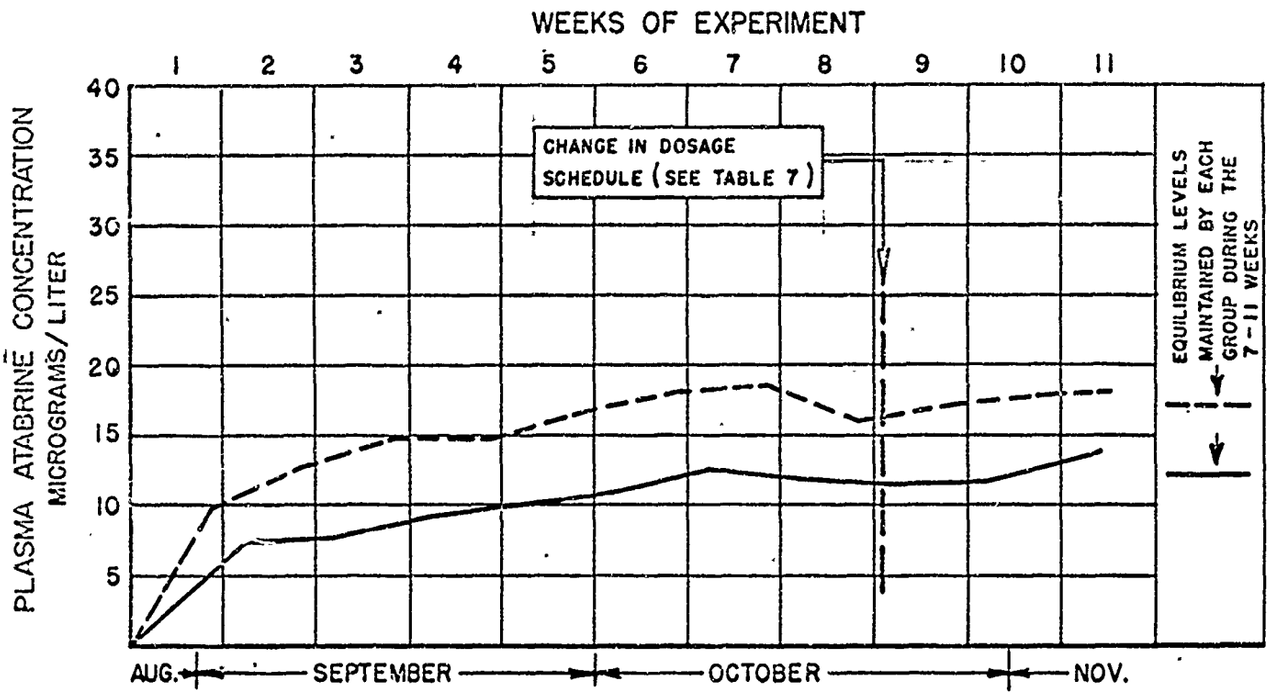


CHART—17

CHART—17

CHART-18

COMPARISON OF MEAN$_G$ WEEKLY PLASMA ATABRINE LEVELS IN TWO GROUPS OF MEN ON DIFFERENT DOSAGE SCHEDULES (H_1 VALUES)



——— MEAN$_G$ WEEKLY LEVEL ON GROUP RECEIVING 0.4 GM./WEEK (84-100 MEN)

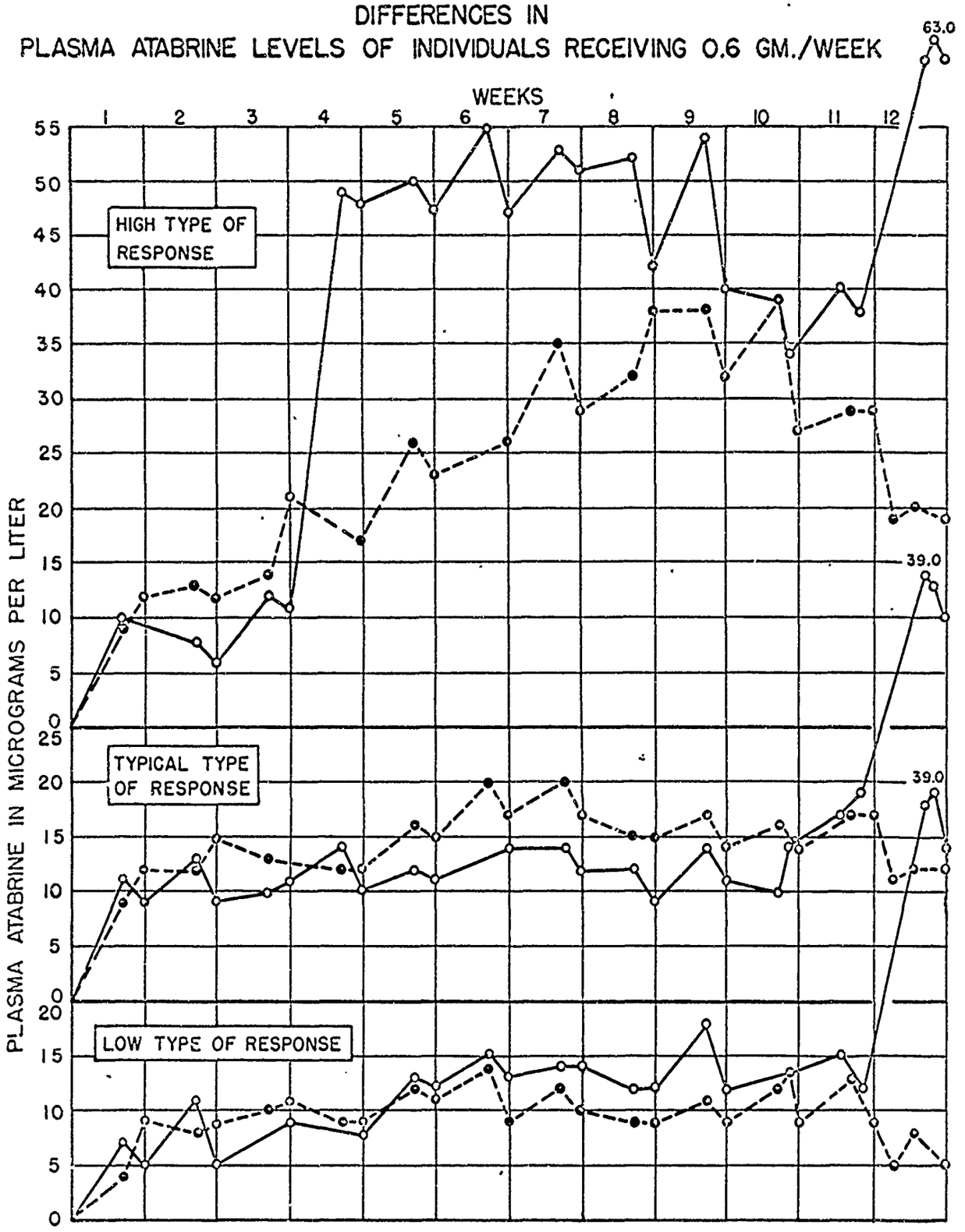
– – – MEAN$_G$ WEEKLY LEVEL ON GROUP RECEIVING 0.6 GM./WEEK (84-100 MEN)

CHART-18

CHART—19

DIFFERENCES IN

PLASMA ATABRINE LEVELS OF INDIVIDUALS RECEIVING 0.6 GM./WEEK



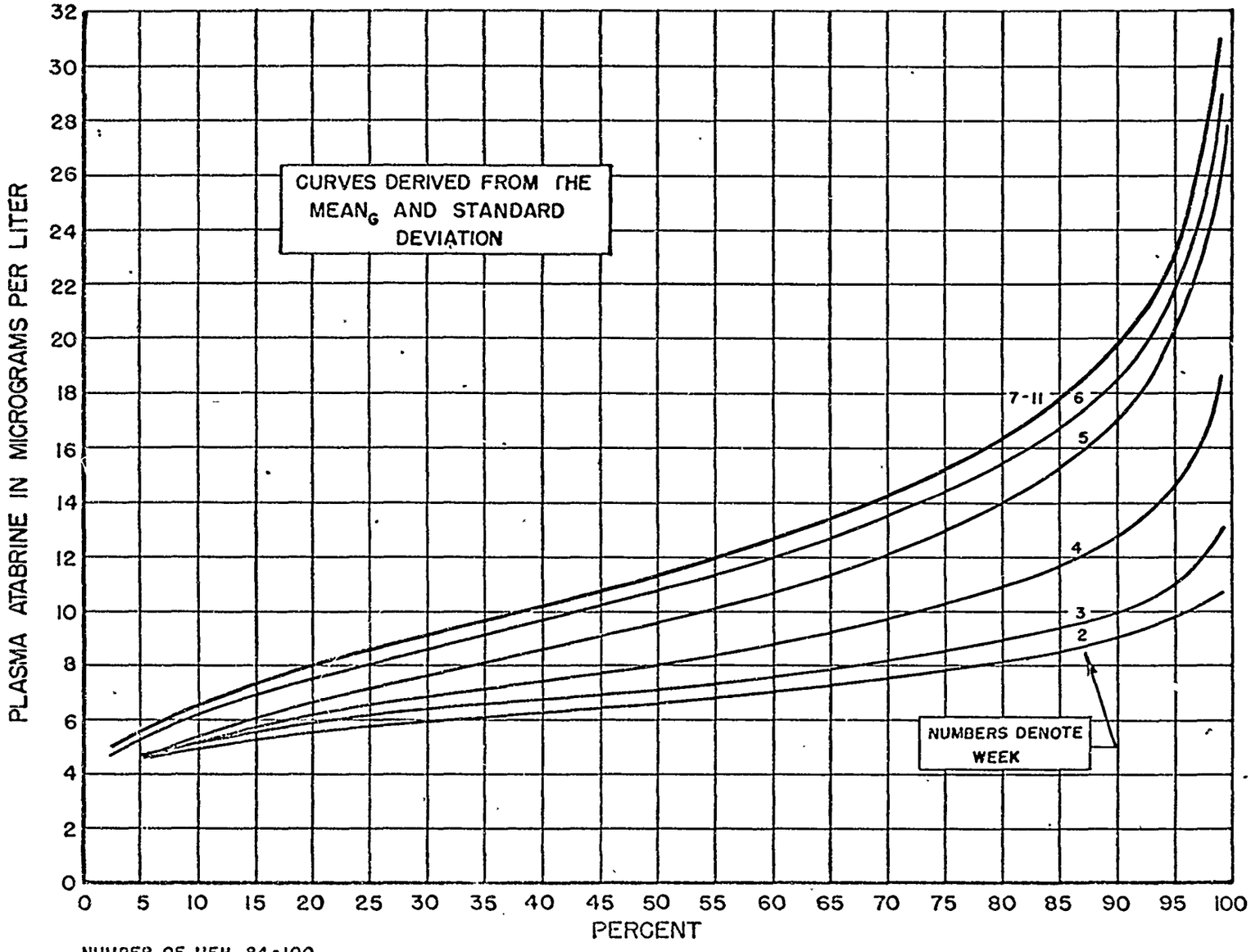
o—o MEN RECEIVED SUPPRESSIVE DOSAGE DURING WEEKS 1-11, THERAPEUTIC DOSAGE DURING WEEK 12

o--o MEN RECEIVED SUPPRESSIVE DOSAGE DURING WEEKS 1-11; NO DRUG DURING WEEK 12

CHART-19

CUMULATIVE FREQUENCIES OF MINIMUM WEEKLY PLASMA ATABRINE LEVELS OF GROUPS OF MEN

(A.R.T.C. COMPANIES B & C) RECEIVING 0.4 GM. / WEEK

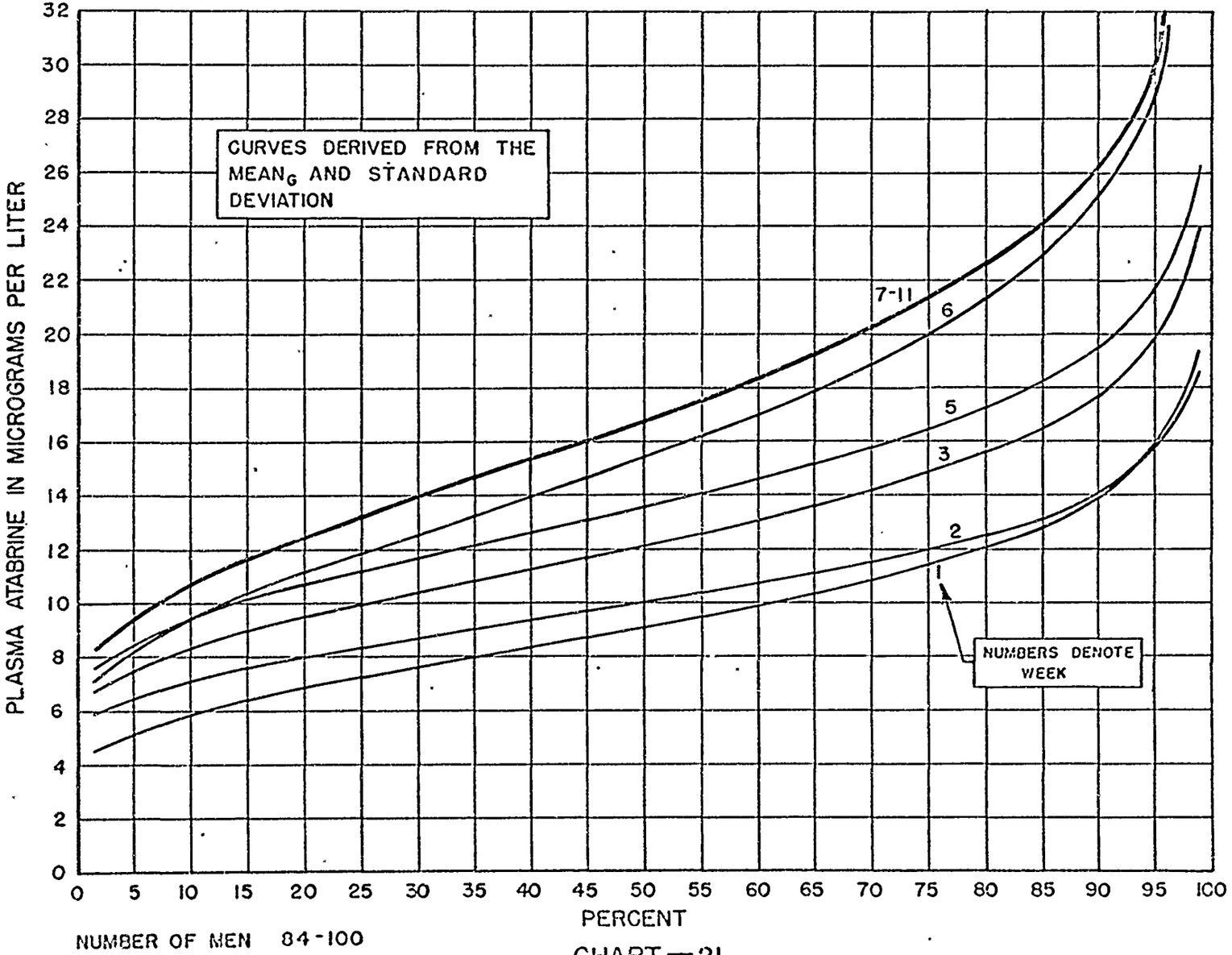


NUMBER OF MEN 84-100

CHART – 20

CHART – 20

CUMULATIVE FREQUENCIES OF MINIMUM WEEKLY PLASMA ATABRINE LEVELS OF GROUPS OF MEN
(A.R.T.C. COMPANIES B & C) RECEIVING 0.6 GM./WEEK



NUMBER OF MEN 84-100

CHART — 21

CHART — 21

CLIMATIC CONDITIONS DURING WORK HOURS

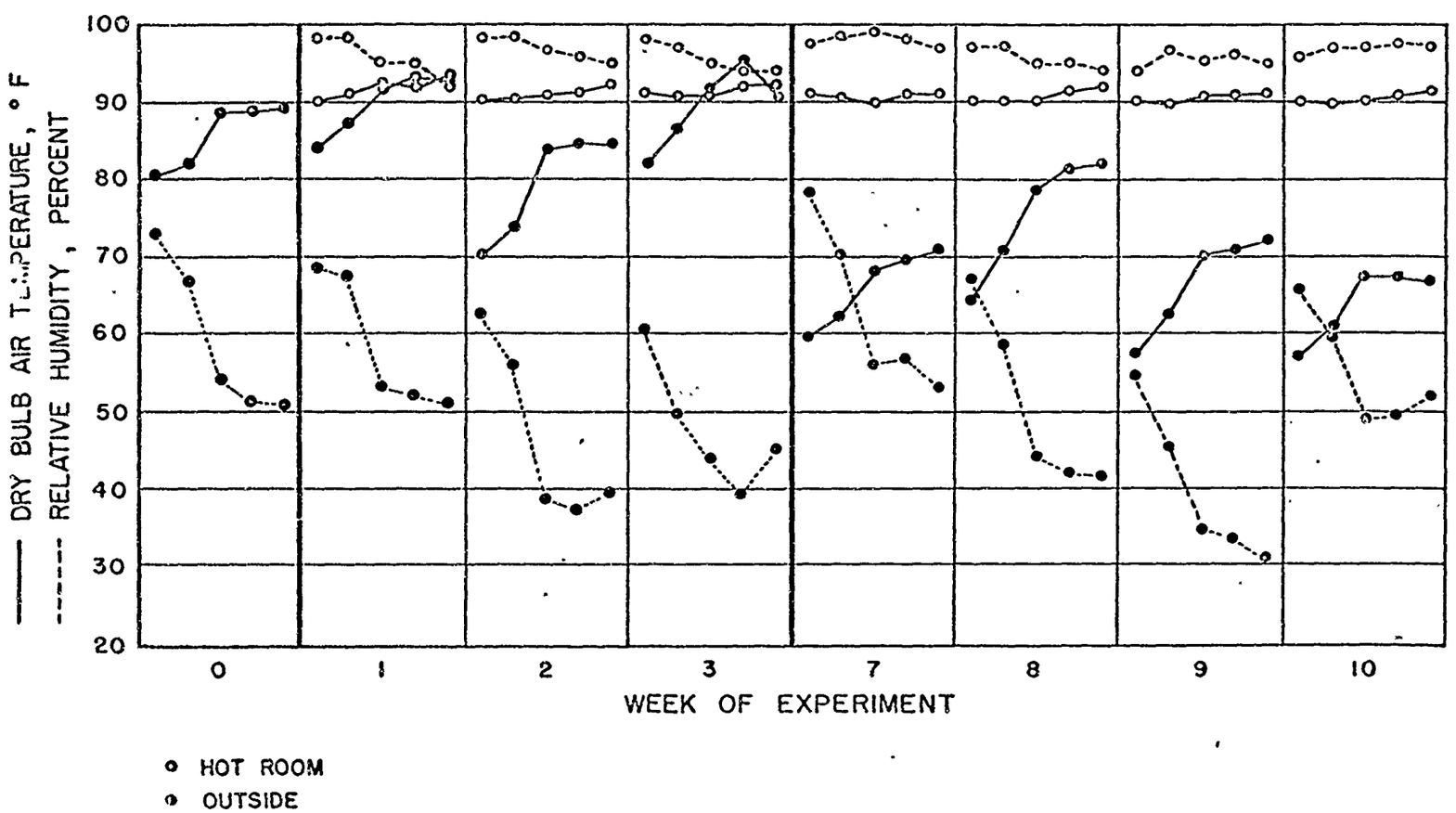


CHART - 22

CHART - 22

CHART - 23

CHANGES IN HEART RATE, RECTAL TEMPERATURE AND BLOOD PRESSURE DURING ACCLIMATIZATION TO WORK IN JUNGLE HEAT

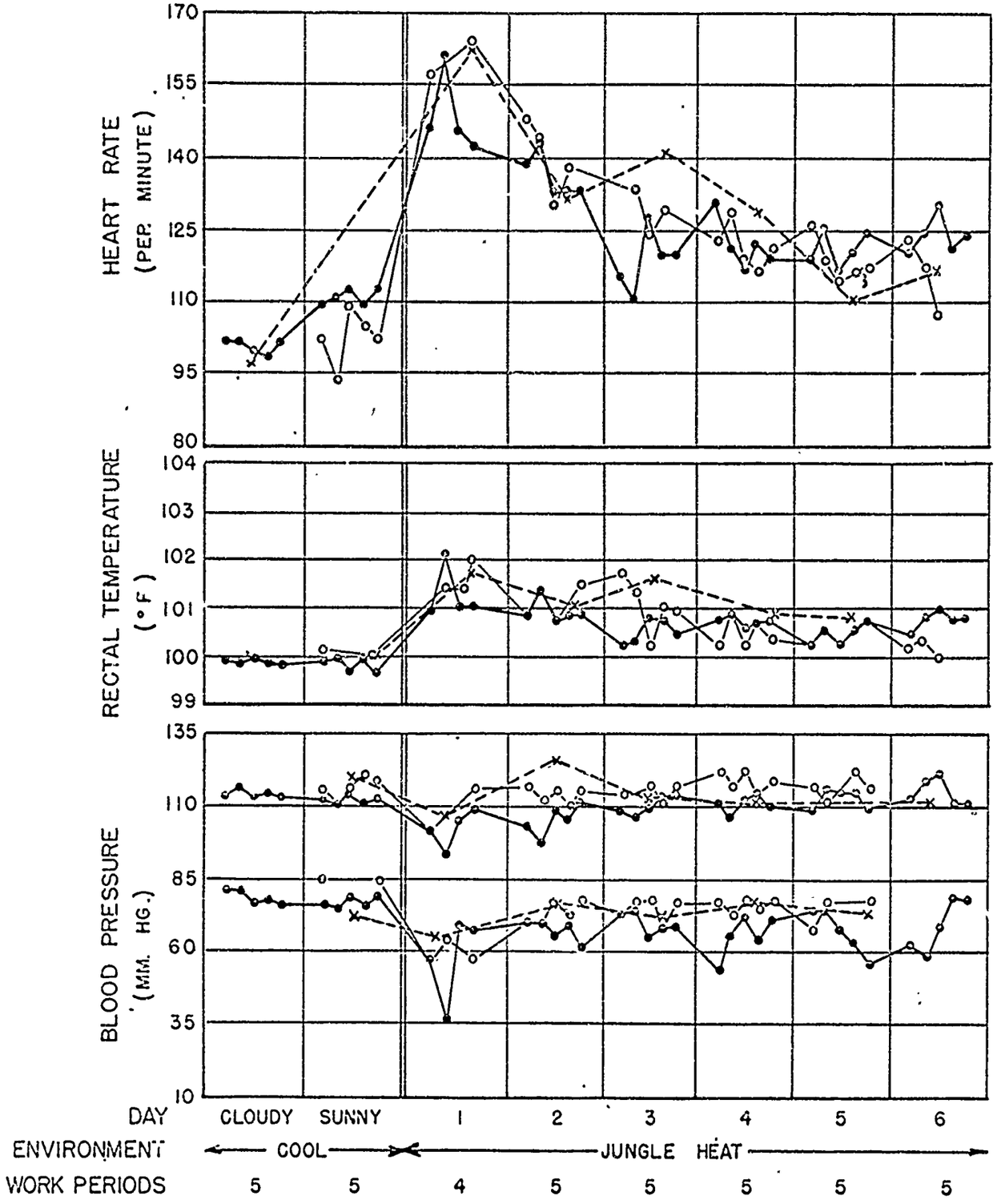
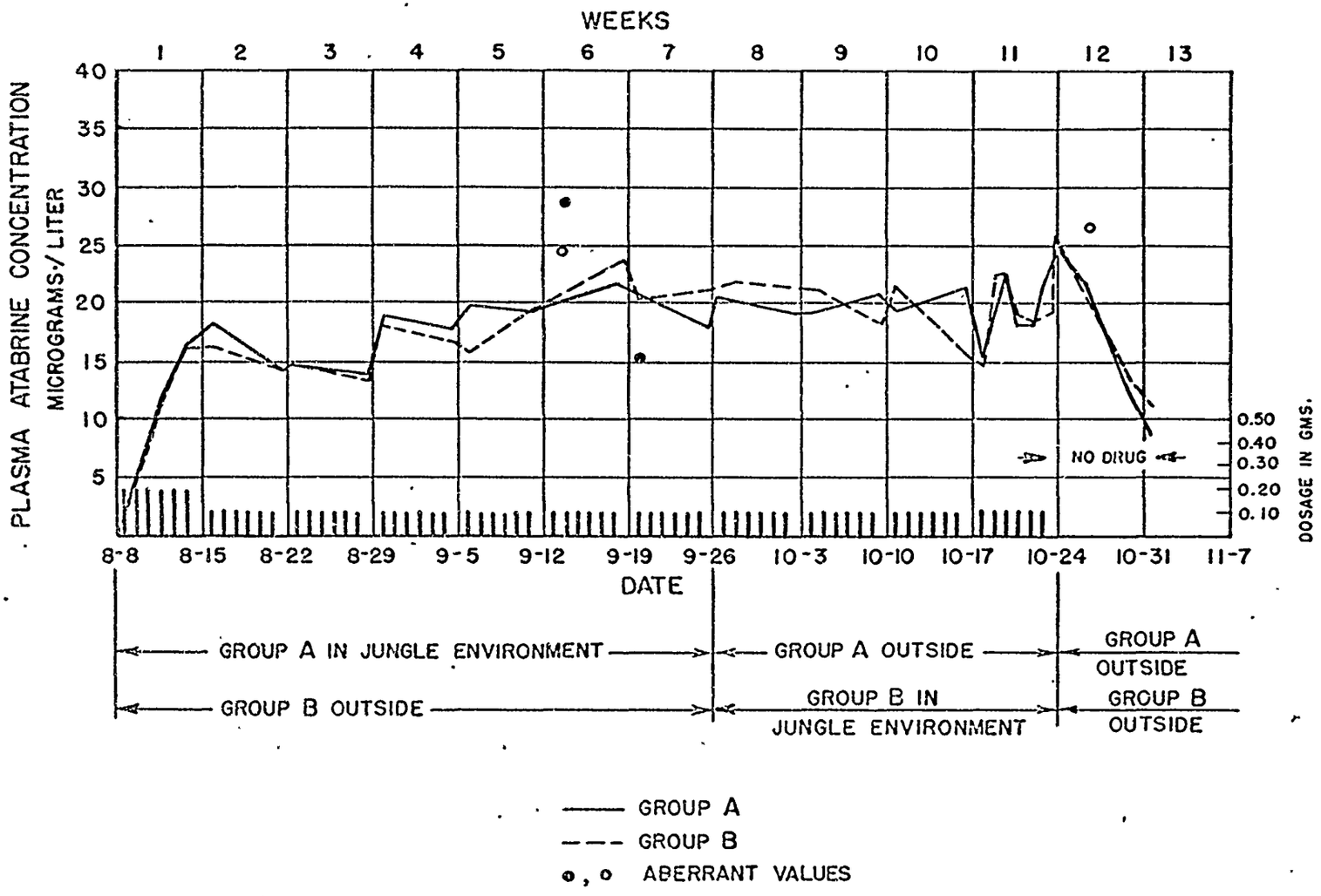


CHART — 23

MEAN$_G$ PLASMA ATABRINE CONCENTRATIONS; JUNGLE GROUPS



—— GROUP A

– – – GROUP B

●, ○ ABERRANT VALUES

CHART – 24

CHART - 24

HIGH RATE OF SWEAT LOSS IN JUNGLE DOES NOT AFFECT PLASMA ATABRINE CONCENTRATION

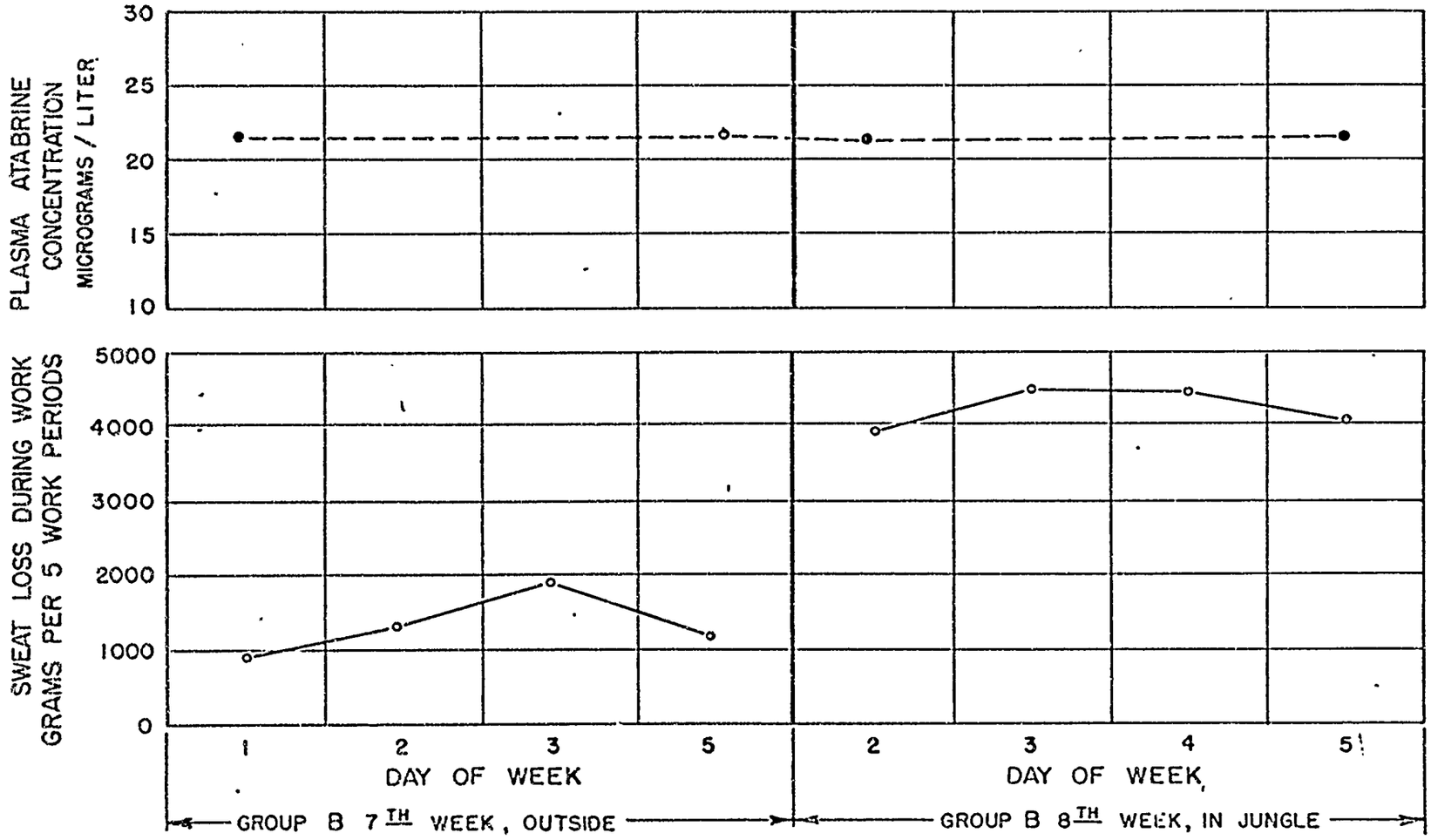


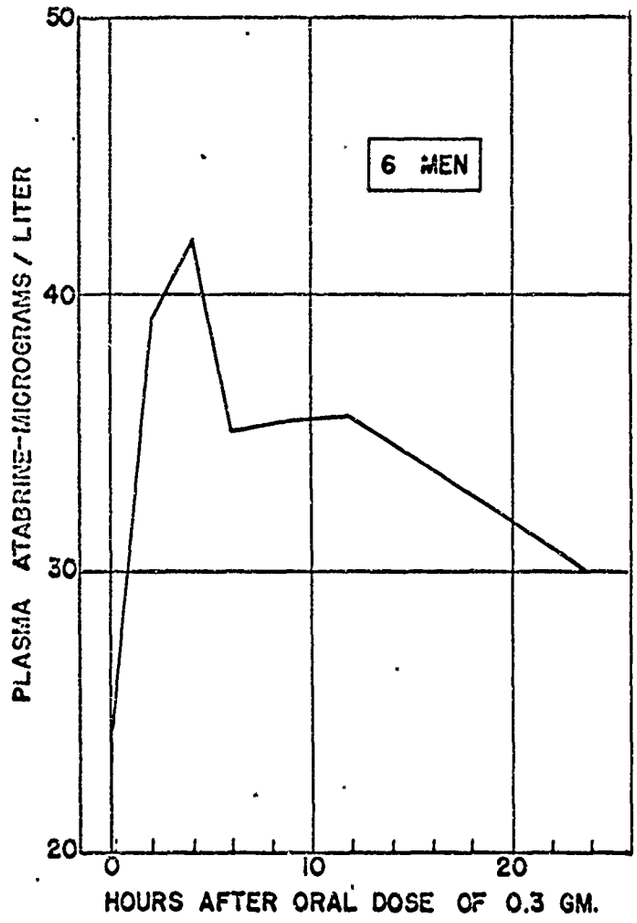
CHART – 25

CHART – 25

CHART– 27

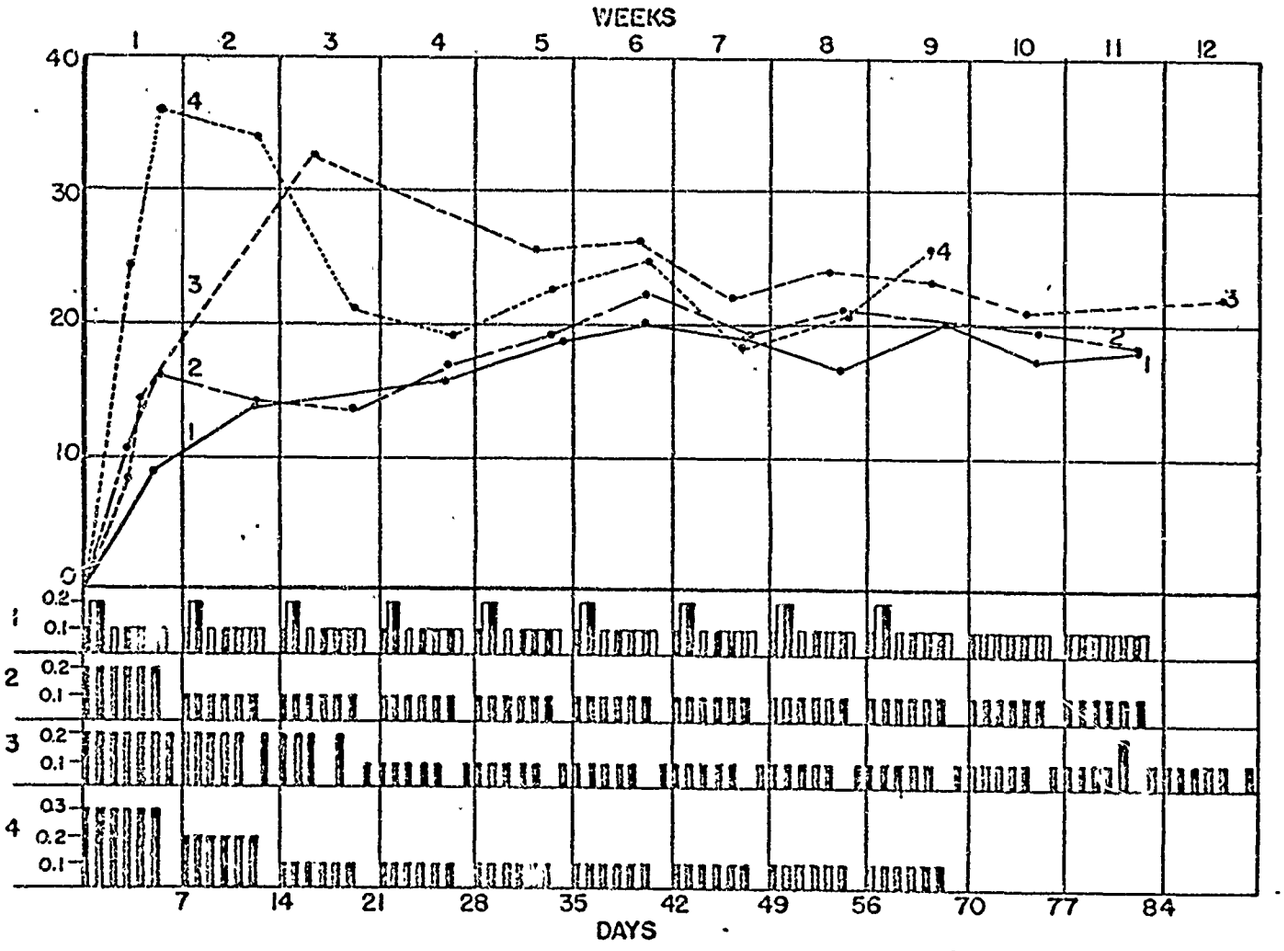
POST ABSORPTION CURVE OF PLASMA ATABRINE

FOLLOWING 4TH DAILY DOSE OF 0.3 GM



CHART– 27

PLASMA ATABRINE LEVELS OBTAINED WITH DIFFERENT PRIMING DOSES
MAINTENANCE DOSAGE, 0.6 GM. / WEEK



1. COS. B & C, SECT. 2, 100 MEN
   CO. B DOSE SOLID BARS
   CO. C DOSE OPEN BARS
2. GROUPS A & B, 30 MEN
3. GROUPS C_1 & C_2, 8 MEN
4. GROUPS C_3, 6 MEN

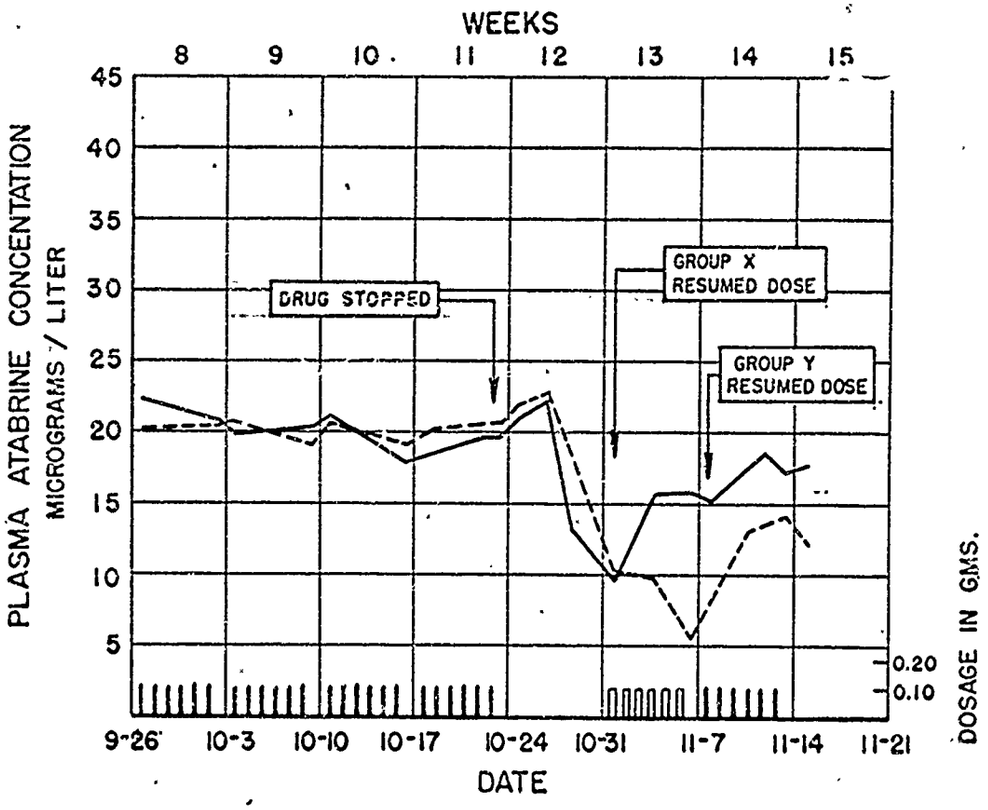
CHART- 28

CHART-28

CHART – 29

INFLUENCE OF INTERRUPTION OF DOSAGE ON PLASMA ATABRINE LEVELS

(0.6 GM. / WEEK SCHEDULE, 30 MEN)

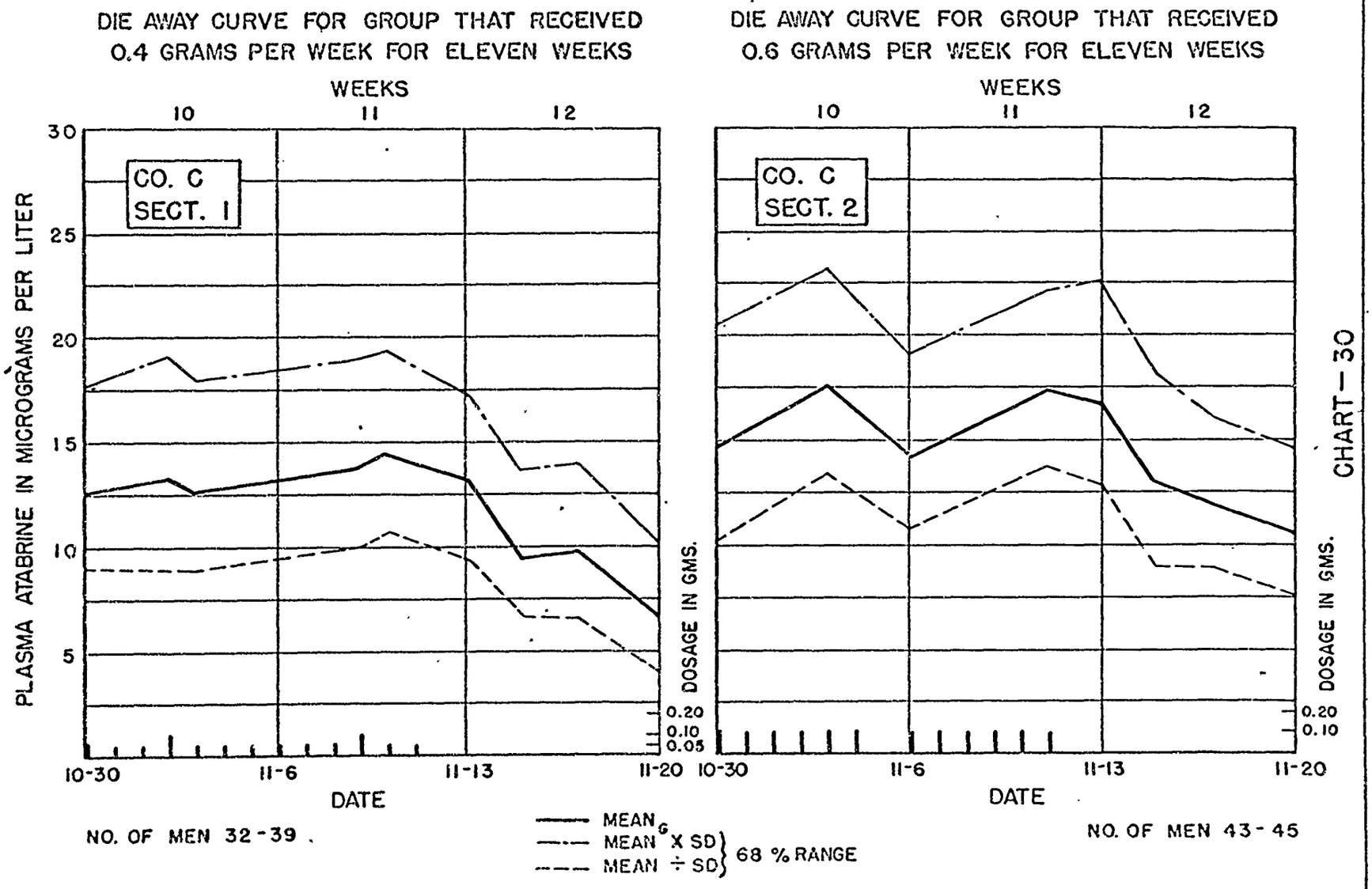


——— GROUP X (MEAN$_G$ OF 15 MEN)

– – – – GROUP Y (MEAN$_G$ OF 14 MEN)

CHART – 29

$MEAN_G$ PLASMA ATABRINE LEVELS OF TWO GROUPS OF MEN FOR ONE WEEK AFTER DISCONTINUING SUPPRESSIVE THERAPY



CHART—30

CHART — 31

$MEAN_G$ PLASMA ATABRINE LEVELS OF TWO GROUPS OF MEN RECEIVING THERAPEUTIC DOSAGE FOR ONE WEEK

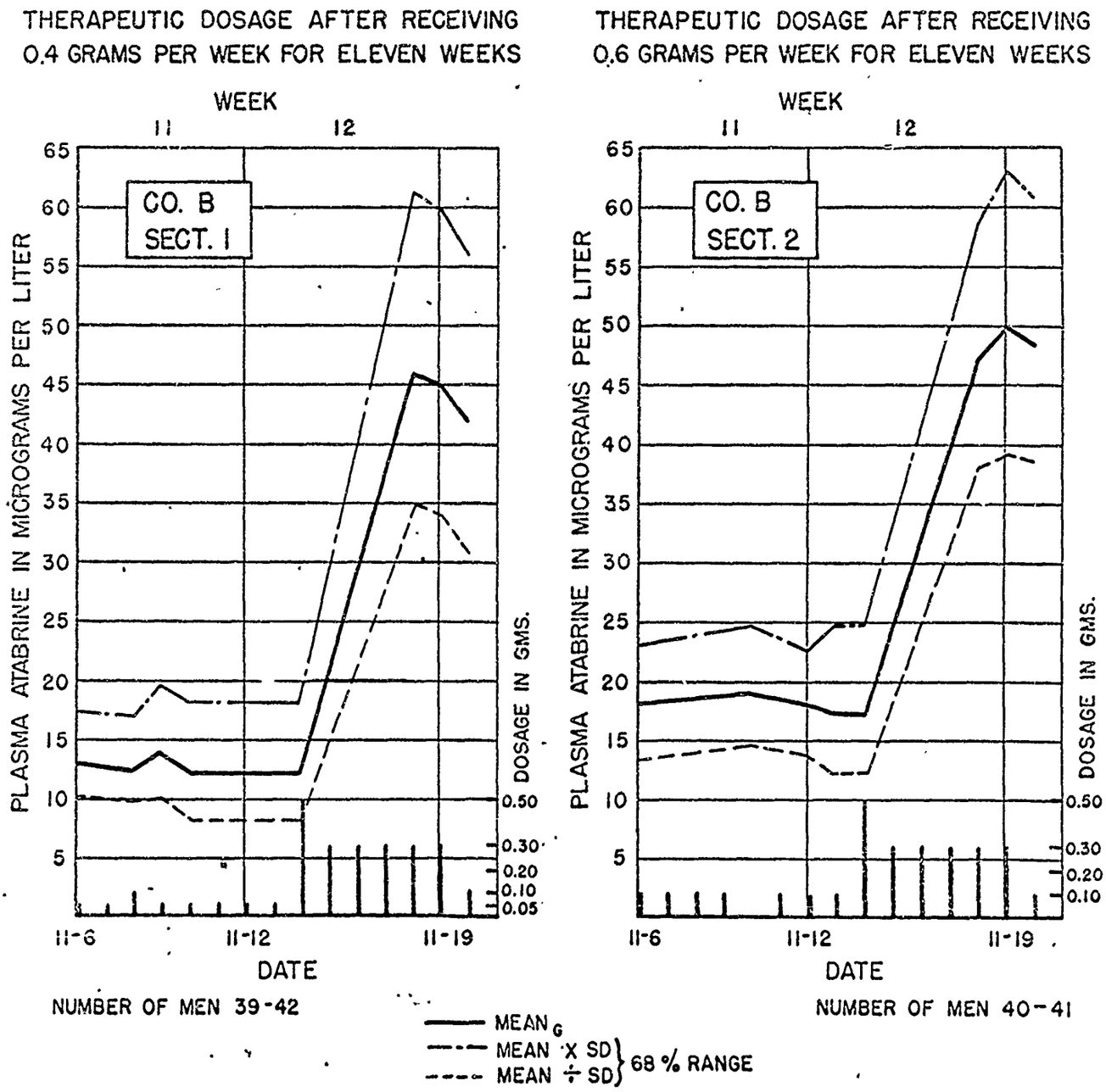


CHART — 31

RELATIONSHIP BETWEEN LEVEL ATTAINED ON SUPPRESSIVE THERAPY
AND LEVEL REACHED ON THERAPEUTIC DOSES

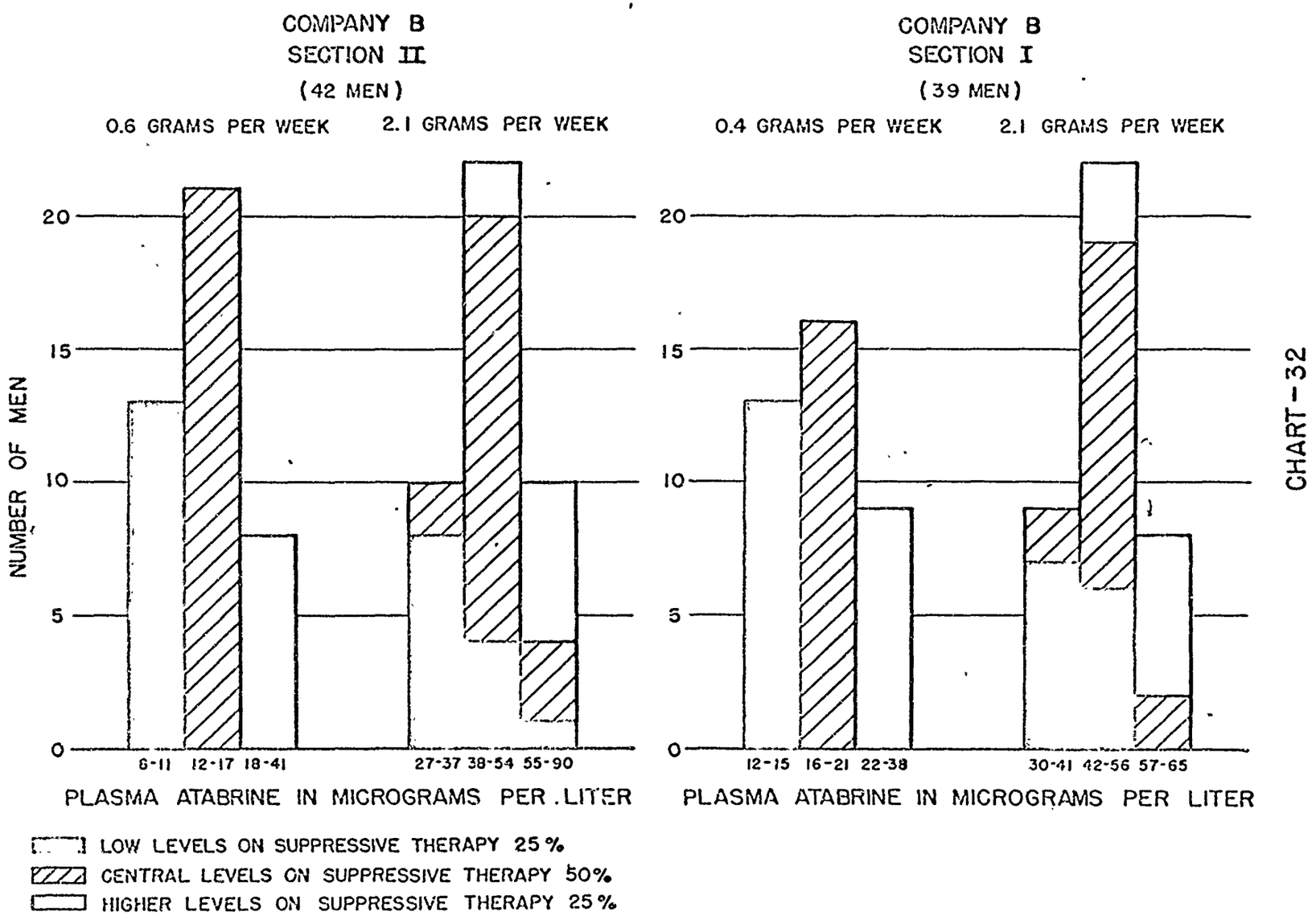
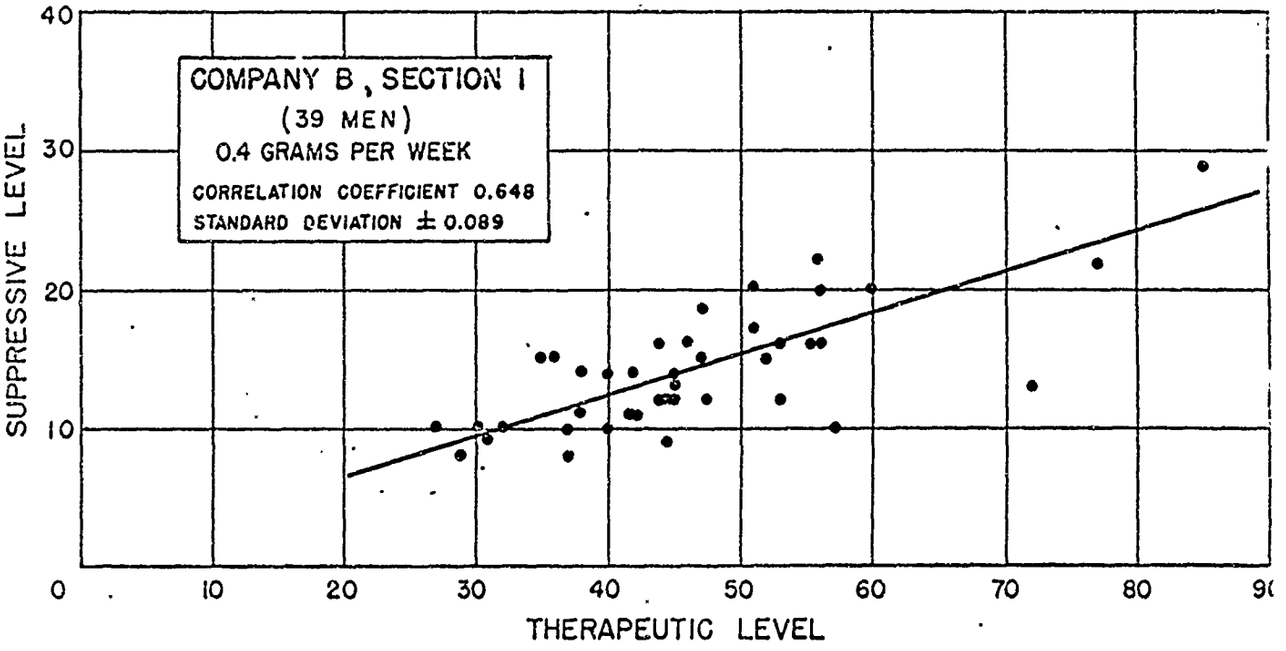


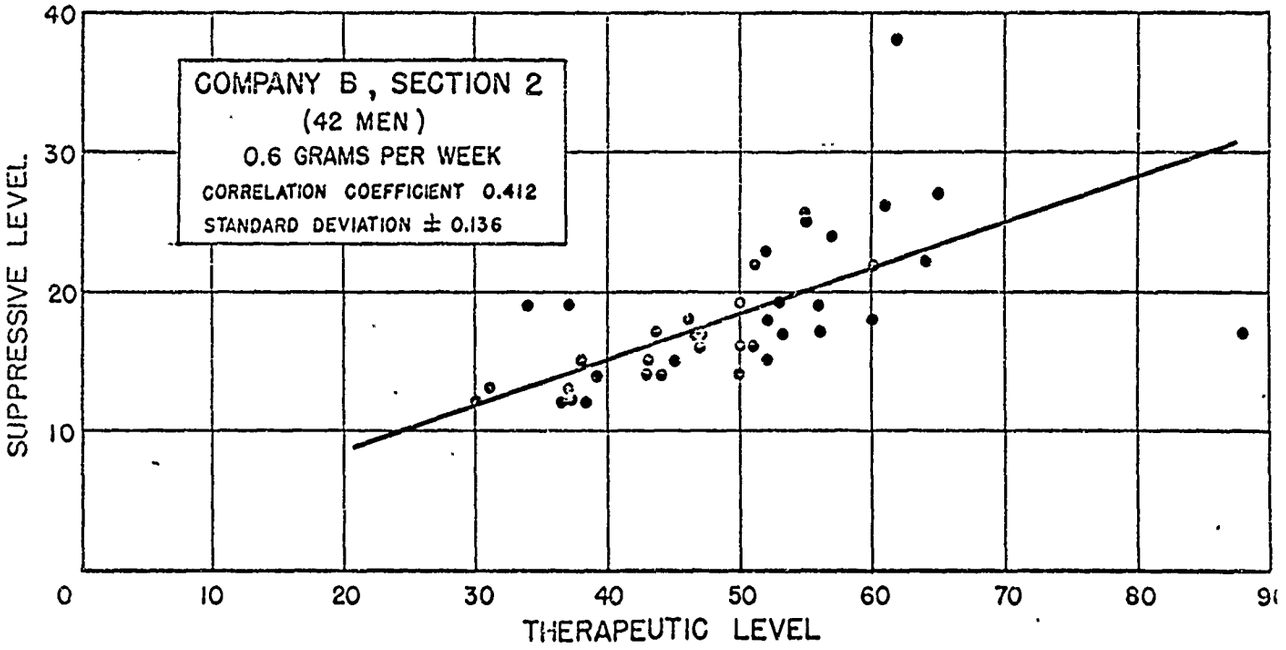
CHART - 32

CHART - 32

CHART – 33

RELATIONSHIP BETWEEN PLASMA ATABRINE LEVEL ATTAINED ON SUPPRESSIVE THERAPY AND LEVEL REACHED ON THERAPEUTIC DOSES





BOTH GROUPS RECEIVED 2.1 GRAMS PER WEEK
ON THE THERAPEUTIC REGIMEN

CHART – 33

RELATIONSHIP OF PLASMA PROTHROMBIN TIME TO PLASMA ATABRINE LEVEL

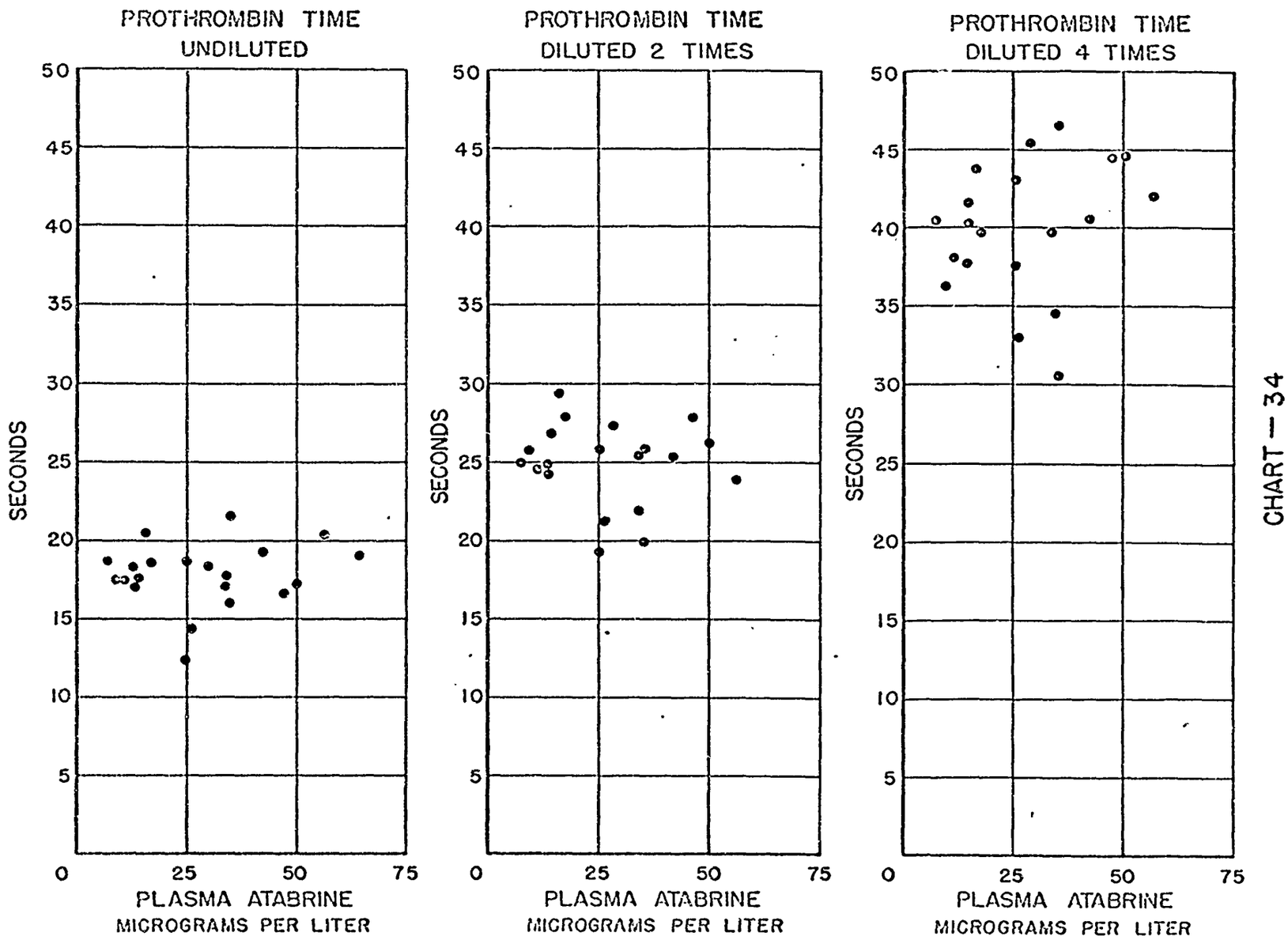
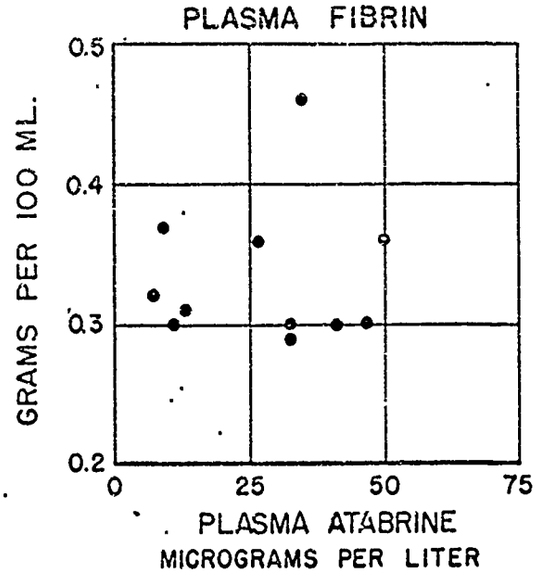


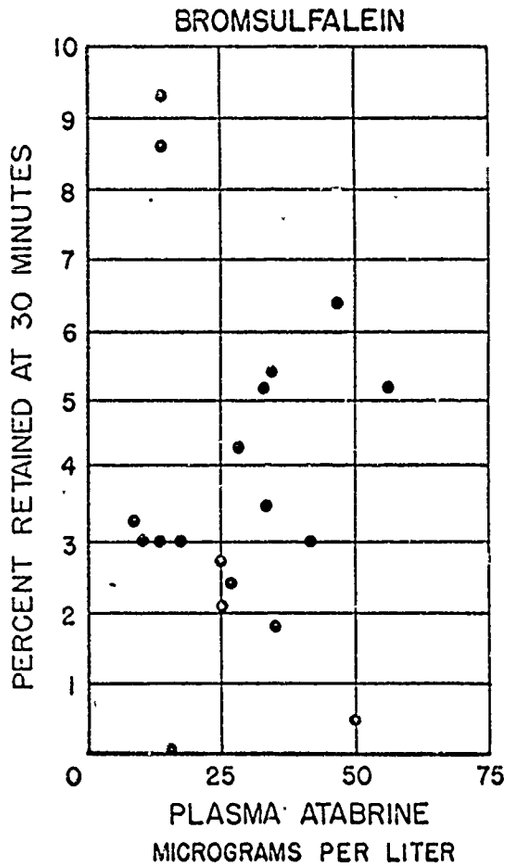
CHART — 34

CHART — 34

CHART — 35

RELATIONSHIP OF PLASMA FIBRIN CONCENTRATION AND BROMSULFALEIN EXCRETION TO PLASMA ATABRINE LEVEL





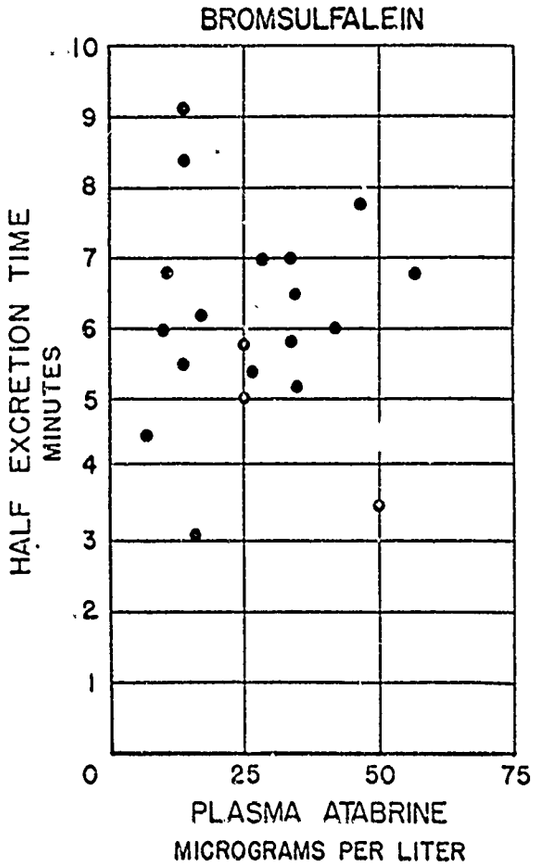


CHART — 35

24 HOUR EXCRETION OF ATABRINE
IN RELATION TO PLASMA ATABRINE LEVEL

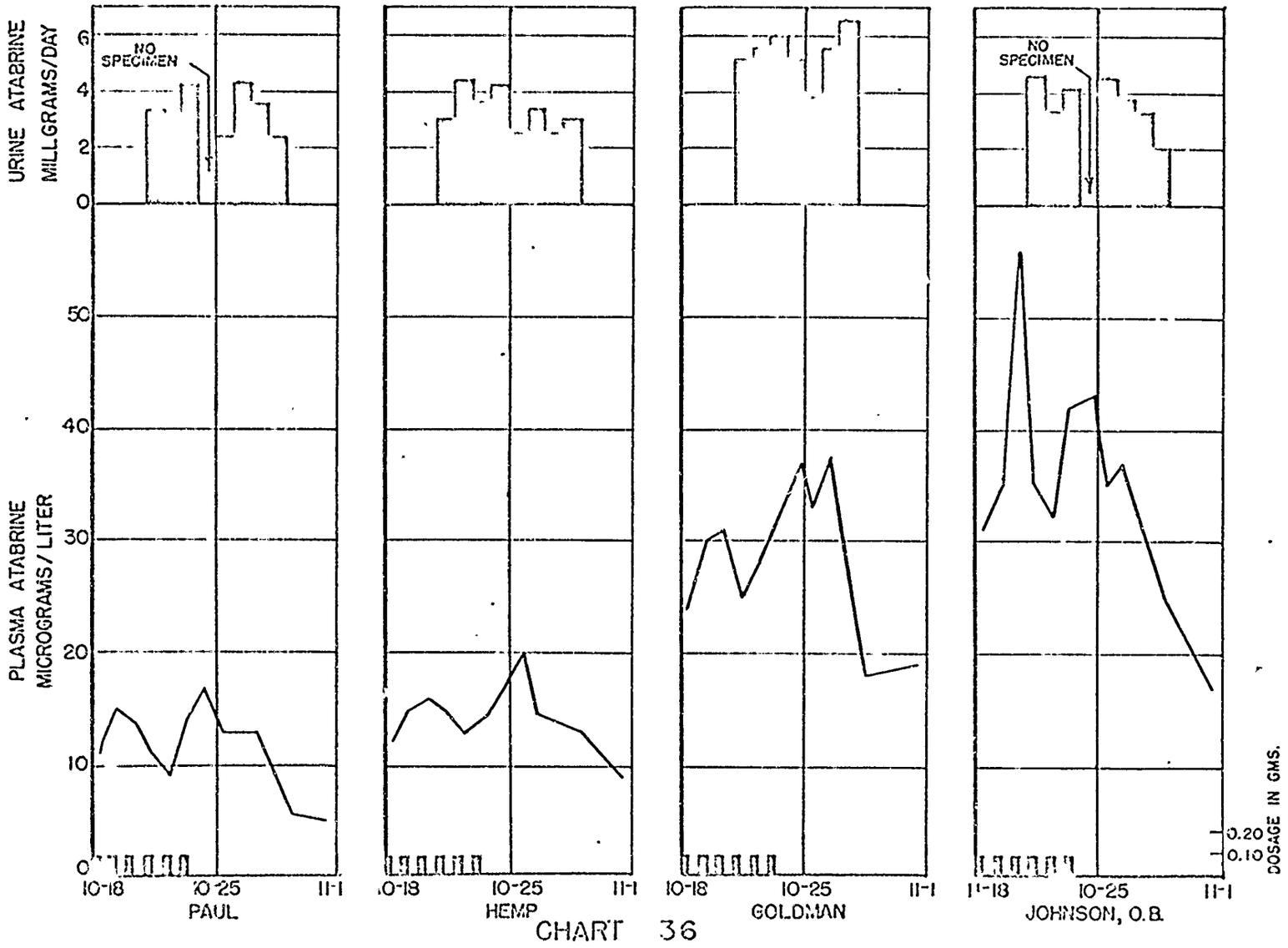
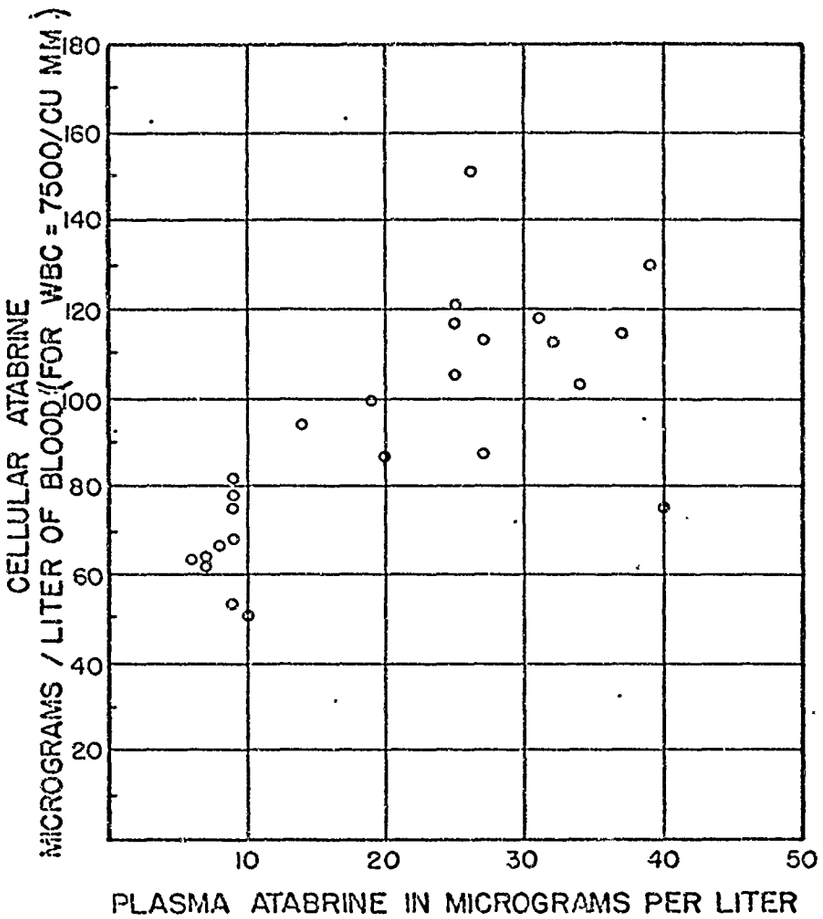


CHART 36

CHART-36

PROPORTIONALITY BETWEEN PLASMA ATABRINE
AND CELLULAR ATABRINE
0.6 GM. GROUP



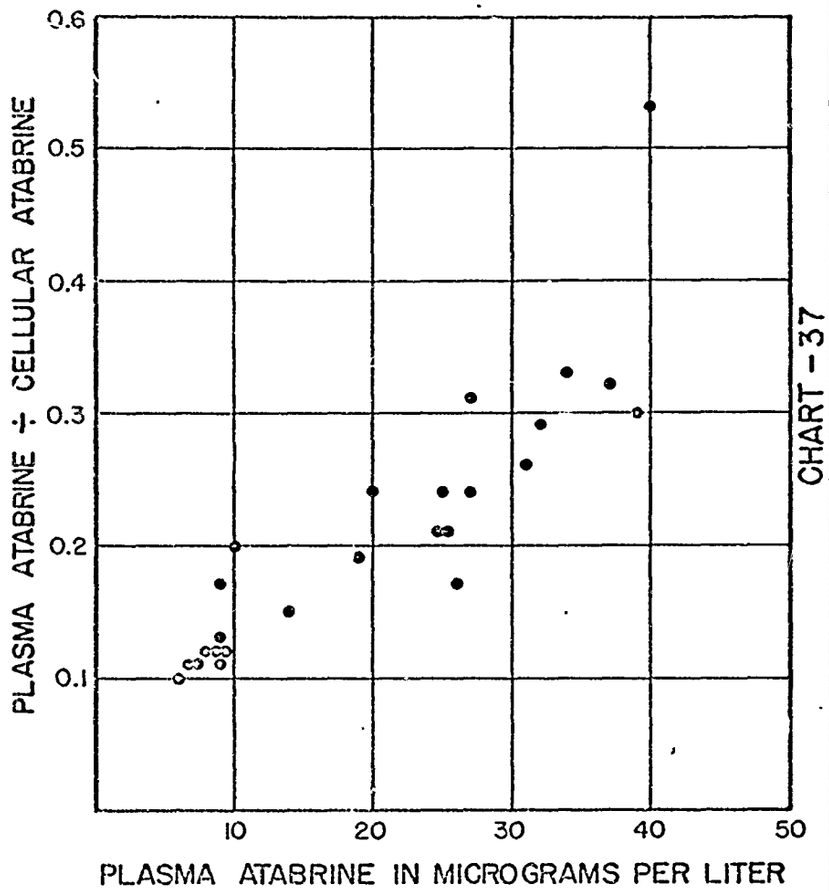
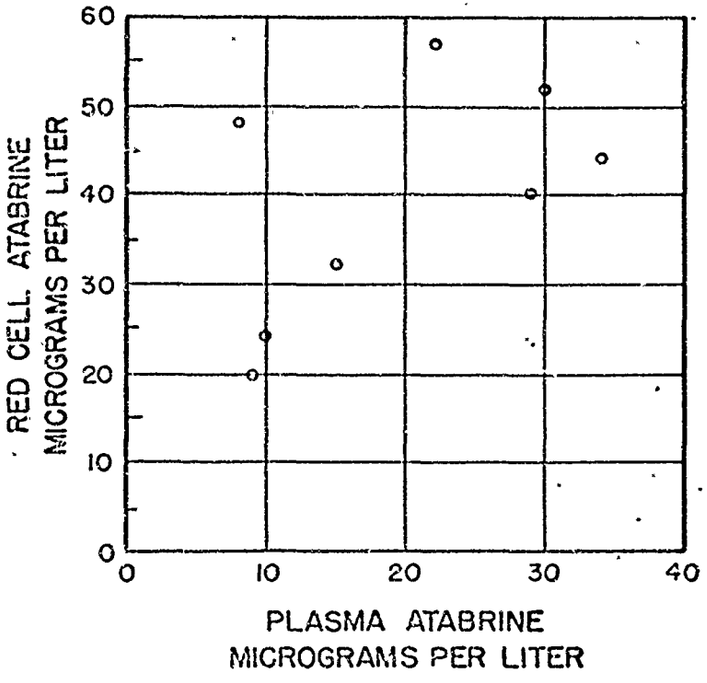


CHART - 37

CHART - 37

PROPORTIONALITY BETWEEN PLASMA ATABRINE
AND RED CELL ATABRINE



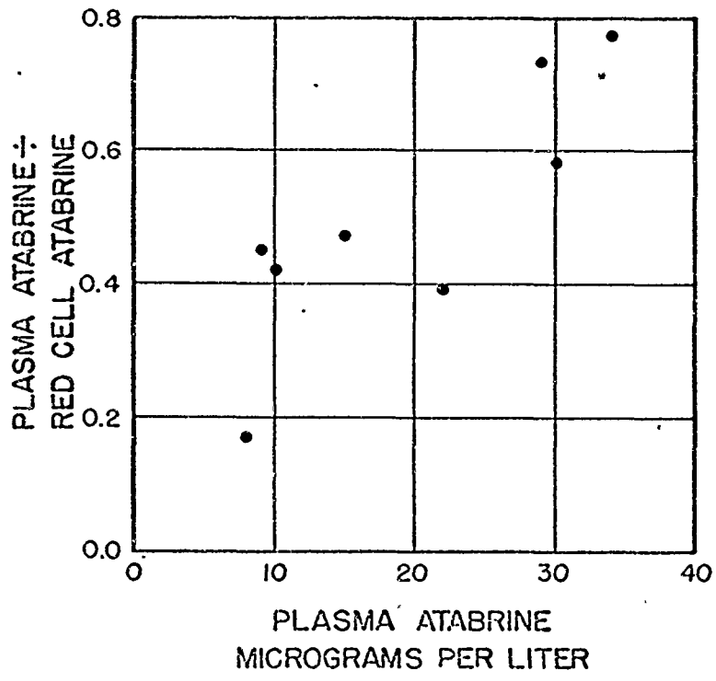
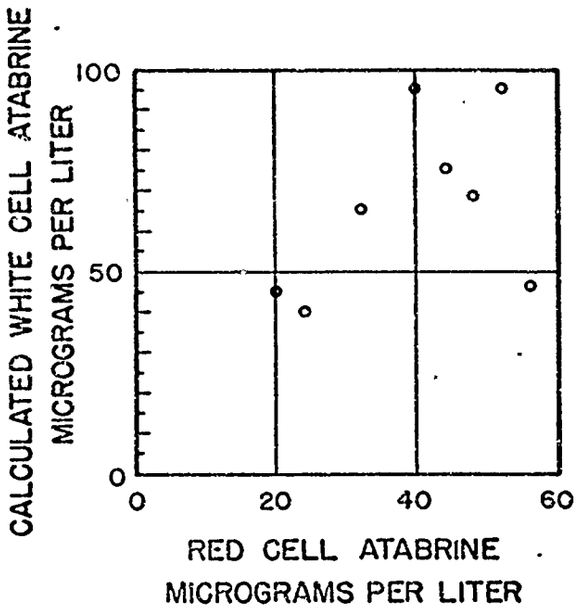


CHART - 38

CHART - 38

PROPORTIONALITY BETWEEN WHITE CELL AND RED CELL ATABRINE



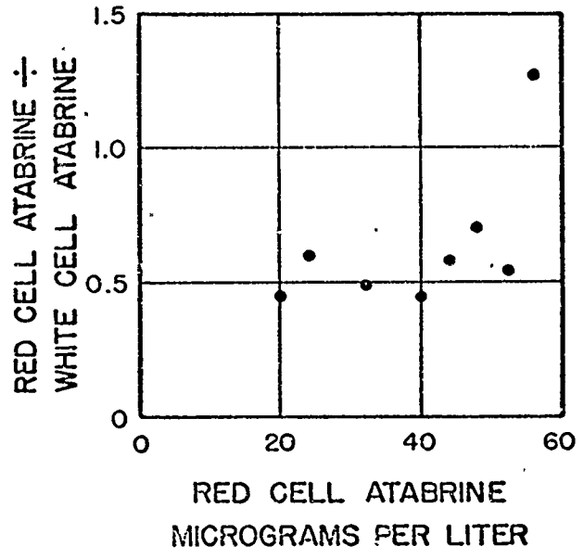


CHART - 39

CHART - 39

COMPARISON OF PLASMA AND CELLULAR ATABRINE LEVELS

IN EIGHT SUBJECTS

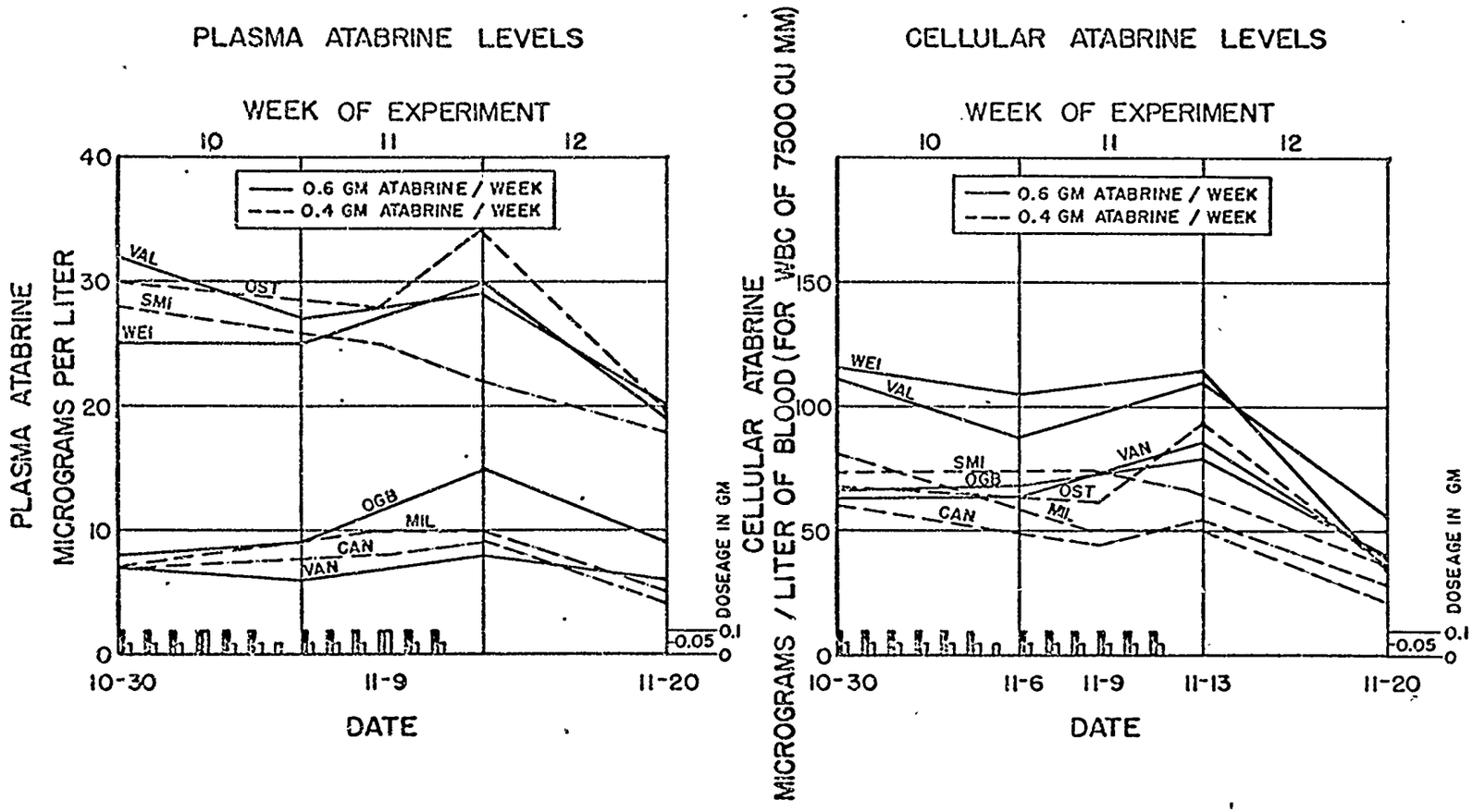


CHART - 40

CHART - 40

PREDICTED DISTRIBUTION OF PLASMA ATABRINE LEVELS

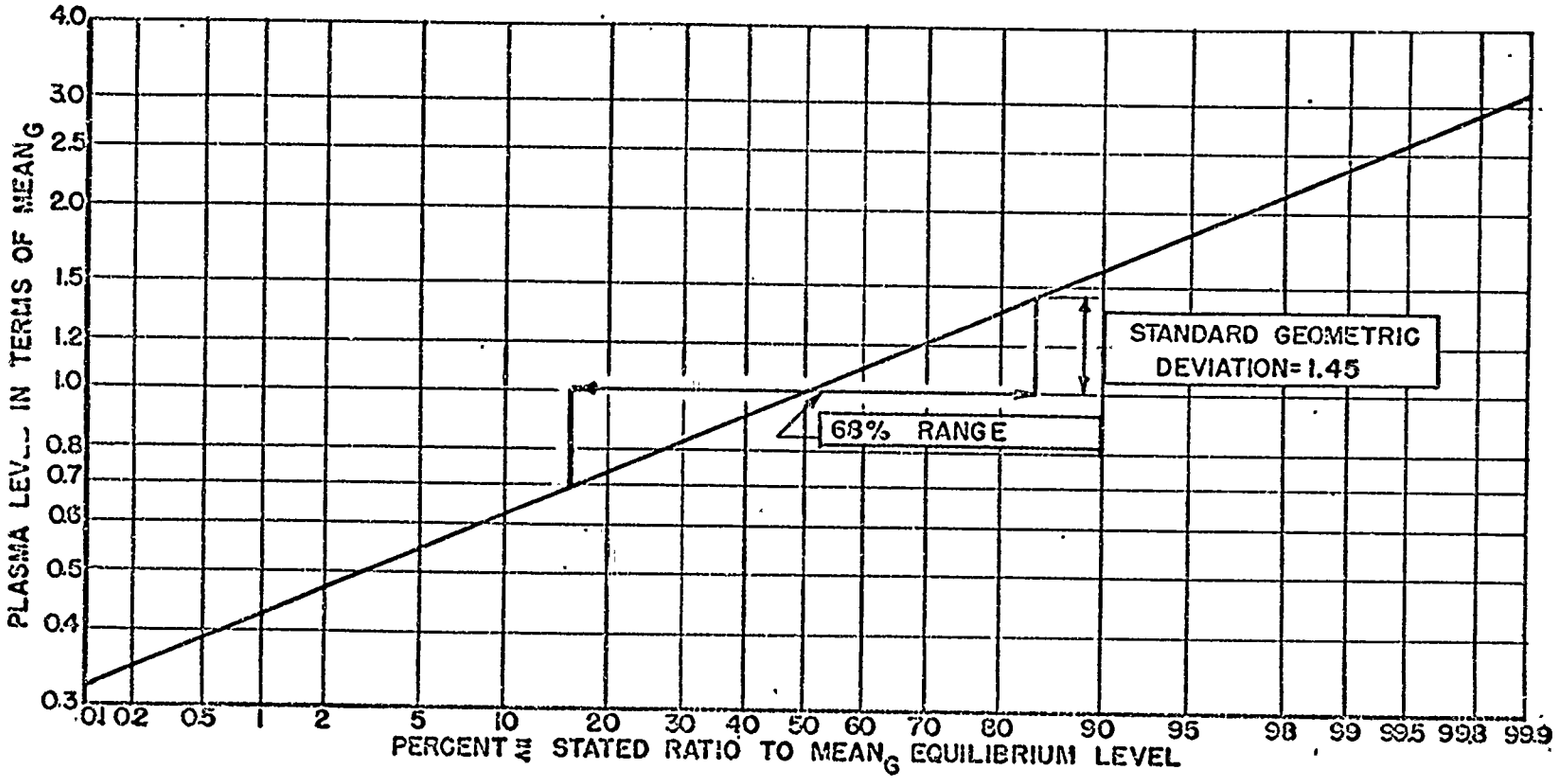


CHART-41

CHART-41